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JOINT SERVICES HIGHWAY SHOCK INDEX PROJECT

John H. Grier, et al

Military Traffic Management Command
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ENGINEERING REPORT

JOINT SERVICES HIGHWAY SHOCK INDEX PROJECT

Prepared by

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JUNE 1975

MILITARY TRAFFIC MANAGEMENT COMMAND

TRANSPORTATION ENGINEERING AGENCY

NEWPORT NEWS, VIRGINIA 23606

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This work represents the first known attempt to develop a procedure for classifying highway cargo vehicles on the basis of their rough riding characteristics. The procedure cannot be used for predicting the expected highway shock environment but can be used for classification as regards relative magnitude of shock.

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ABSTRACT

The United States Army, Navy, Air Force, and Marine Corps have jointly sponsored and participated in the development of a Shock Index (SI) for highway transportation. A numerical SI associated with a particular vehicle-load combination can now be determined at a low cost by application of simple static field measurements. The SI provides classification for vehicle-load combinations as regards probability of shocks transmitted to the cargo during highway shipments.

This work represents the first known attempt to develop a procedure for classifying highway cargo vehicles on the basis of their rough riding characteristics. The procedure cannot be used for predicting the expected highway shock environment but can be used for classification as regards relative magnitude of shock.

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I. INTRODUCTION

In 1967 representatives of the United States Army, Navy, Air Force, and Marine Corps agreed that it should be possible to establish shock indices that would be representative of the cargo environment for the various transport modes. The Services formed a Steering Committee to intitate and guide the development of a highway shock index. The highway mode was selected because of the relative ease in controlling the environment and related variables.

As an initial step the Steering and Advisory Committee let a $53,000 contract to General Testing, Inc., Springfield, Virginia, to determine and develop a shock index equation that could be used to classify highway cargo vehicles in terms of vehicle shock to the cargo. In addition, and in conjunction with the General Testing, Inc. contract, a second $13,000 contract was let by the joint services committee to J. A. Johnson, Inc., Short Hills, New Jersey, an independent testing organization, to check and verify the General Testing, Inc., project objective. General Testing, Inc., ran a comprehensive group of static and dynamic shock evaluation tests using five classes of cargo trucks.

General Testing, Inc., laboratories released their final report, Development of a Shock Index Classification for Highway Cargo Vehicles, dated 16 April 1971. As described in the report "a set of semi-empirical relationships have been developed to equate the performance of the vehicle/cargo with the significant variables affecting the ride." Conclusions, as presented by General Testing, Inc., are that "the SI equation developed under this contract is the result of an approach to a complex problem. In short, this work is not the ultimate answer to the problem of cargo ride; instead, it represents a foundation on which to build a firm set of requirements for the safe transportability of all cargo."

The bulk of General Testing, Inc., work concerned a controlled laboratory test arrangement. J. A. Johnson, Inc., was tasked to validate the feasibility of the General Testing, Inc., classification procedure and test on public roads to establish the accuracy of method in a practical over-the-road environment. Johnson's work concluded that a shock index classification is both feasible and needed by the military community, but that more engineering expertise is required to improve accuracy prior to adoption of the classification procedure.

Accordingly, Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) initiated a comprehensive shock index field test program using Fort Eustis facilities, military equipment, and personnel to assist in obtaining program objectives by developing a practical test to obtain usable impact data. A military 5-ton M52 tandem tractor, in combination with a 12-ton M127 tandem trailer, was used for this phase of the test program. Using military personnel and equipment considerably reduced research costs and assured technical control of the field work. As a result of these tests a procedure for testing commercial cargo trucks was developed.

During July 1973, limited field tests were initiated on the first of three leased commercial cargo trucks; all field work was completed by April 1974. Support for these tests was provided by the US Army Transportation Center and Fort Eustis. Planning, supervision of tests, analyses, and development of concepts and application were performed by MTMCTEA engineers

The detailed procedure on how to determine the shock index for a typical highway cargo truck is contained in this report.

II. OBJECTIVES

1. To conduct static loading and dynamic impact tests on a representative series of commercial highway cargo trucks to obtain data for determining the shock force transmitted into the cargo bed.

2. To analyze the static and dynamic data collected from the tests and to develop a method from the results for determining the shock index for commercial cargo trucks.

III. CONCLUSIONS

1. A practical, graphic method, which utilizes the planned payload(s) and vehicle payload axle spring rate, has been developed for determining the shock index of commercial cargo trucks.

2. For a two-axle cargo truck (truck Type I), the roughest ride on a truck cargo bed was over the rear axle. For a truck-tractor-semitrailer combination (truck Types II and III), the roughest ride occurred either over the rear axles of the trailer or over the tractor rear axles depending on which axle had the higher payload spring rate.

3. The test vehicles represented the low, middle, and high payload rates for typical trucks used in the transportation industry.

4. The tests showed that of the three major variables, percent of maximum payload, tire pressure, and speed, percent of maximum payload

has the most effect on shock index. Tire pressure, in the practical range, and speed caused relatively minor changes.

5. For the highway mode vertical accelerations (impact forces) are generally greater than lateral or longitudinal accelerations and are a major factor as regards potential cargo damage.

6. High, erratic shock values occurred with very light or maximum payloads. The most erratic results occurred over the fifth wheel area.

7. While under full or minimum load conditions, independent of load location, tire pressure, or truck speed, vertical accelerations or impact forces exceeding 10g were recorded on several occasions by each of the forward, middle, and rear impact registers, when the test vehicles ran over the test bumps.

8. The shock index graph may be employed to define practical shock parameters for selection of cargo trucks based on riding performance and for preparing cargo truck specifications or standards.

IV. GENERAL

The shock index program was initiated and conducted to obtain practical research information on the impact forces induced upon Government items transported by cargo trucks in order that the Department of Defense would have reference criteria with which to coordinate cargo vehicle compatibility with materiel load characteristics.

A systematic testing approach was held constant throughout the project to produce data output representative of a highway transportation shock environment. Repeatability of shock values was considered of prime importance for the various combinations of test variables.

Well-trained military personnel to operate the test support equipment were provided by the US Army Transportation Center and Fort Eustis. Their skills and knowledge greatly reduced research costs and assured MTMCTEA engineers complete technical control of the field work during several hundred static and dynamic runs on each vehicle.

Late model 1972 and 1973 truck and truck-tractor-semitrailer combinations were contracted from a national leasing agency. The rented test vehicles were considered to be most representative of cargo trucks used to transport Government material and, therefore, would produce the desired collective shock data.

The initial phases of the Shock and Vibration Analysis Program are described in MTMTS Interim Report 73-35, Joint Services Shock Index Project.[1/] The preliminary testing performed during the original aspects of the study was jointly financed by the United States Army, Navy, Air Force, and Marine Corps. The joint services were in agreement that establishing the shock forces on the cargo bed of highway trucks could eventually result in a significant savings of materiel replacement and packing costs. Preliminary testing performed during the original aspects of the study established the direction of approach as to test environment and required instrumentation. The original efforts served as a guide in determining methods to obtain results as presented in this report on the comprehensive group of values from the static and dynamic shock and evaluation tests.

The testing of five commercial cargo truck combinations was originally planned; however, because of a funding cut, only three vehicles were tested, and these were considered to be representative of the average trucks used by the transportation industry. Testing a truck-tractor-semitrailer combination equipped with air-ride suspension and loaded with typical household goods would increase the shock index evaluation in defining the impact forces transmitted to cargo.

The work completed to date has resulted in the development of a procedure for determining the shock index of highway cargo vehicles and defined the shock environment on the bed of typical highway cargo trucks. This information can be used to establish cargo truck specifications, or standards, riding performance, packaging standards, and restraint requirements for cargo.

V. DESCRIPTION OF TEST PROCEDURES

TEST VEHICLES

The test vehicles consisted of the following commercial truck and truck-tractor-semitrailer combinations. Rated weights and gross loaded test weights are shown in Table I. The vehicles were tested in the order shown.

Truck Type I

1973 18-foot flatbed stake truck with dual rear wheels, Figure 1.

[1/] MTMTS Interim Report 73-35, Joint Services Shock Index Project, prepared by the Transportation Engineering Agency, December 1973.

TABLE I
RATED WEIGHTS PER TRUCK TYPES (IN POUNDS)

Type	Truck or Tractor (GVW)[b]	Tractor (GCW)[c]	Tractor (GAWR)[a]		Semitrailer GVW Rating	Gross Payload Test Weight
			Front	Rear		
I	23,000	NA	NA	NA	NA	12,520
II	35,000	80,000	12,000	23,000	65,500	39,890
III	28,000	80,000	9,000	19,040	30,950	22,635

a/ GAWR = Gross axle weight rating = Loaded weight on a single axle.
b/ GVW = Gross vehicle weight = Total weight of vehicle (min equip rating) plus weight of driver and passengers and fuel, plus weight of payload.
c/ GCW = Gross combined weight = Gross vehicle weight (GVW) plus weight of semitrailer plus weight of payload.

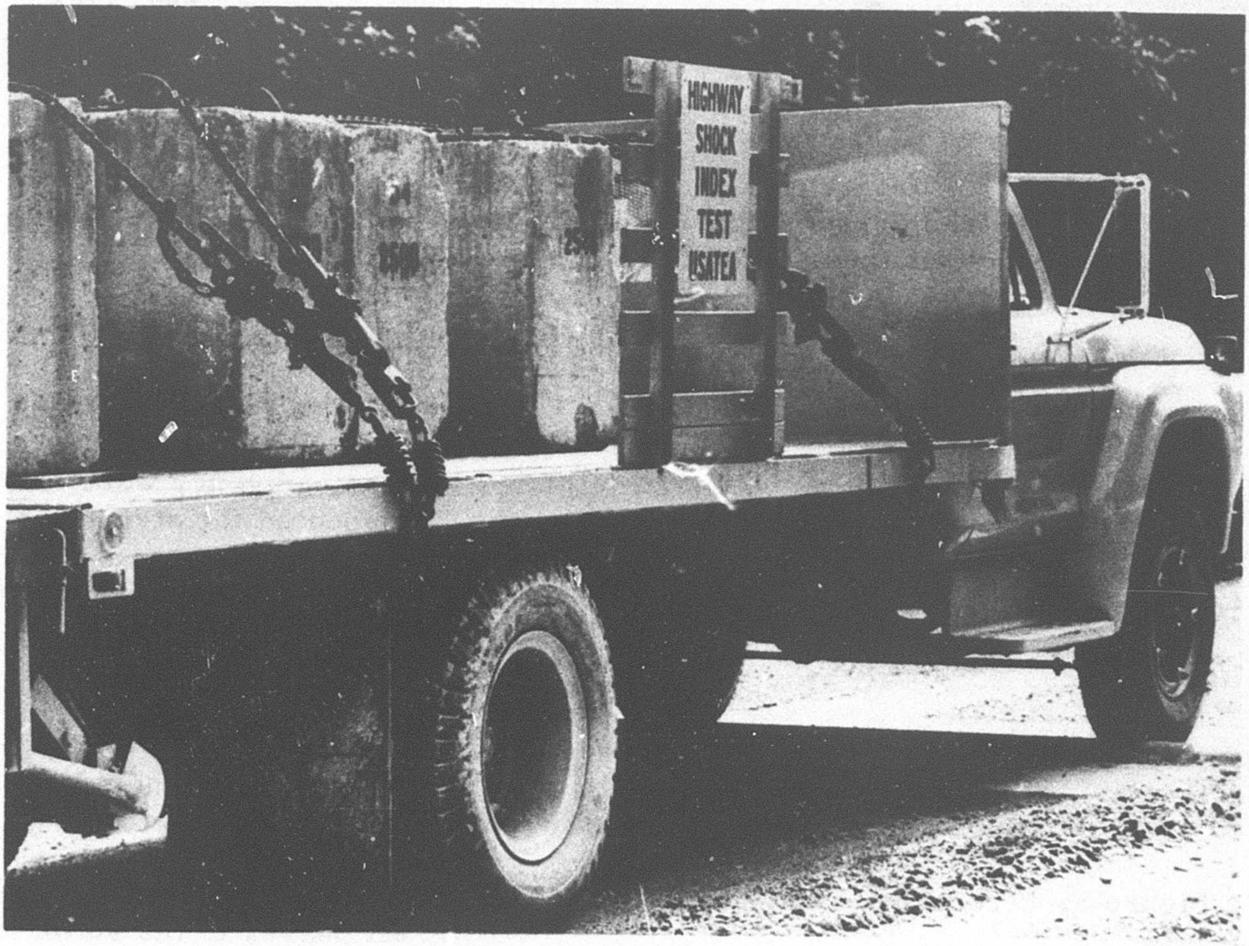


Figure 1. Truck Type I.

Truck Type II

1973 truck-tractor-semitrailer combination: three-axle tractor, two-axle, 40-foot, flatbed, semitrailer, Figure 2.

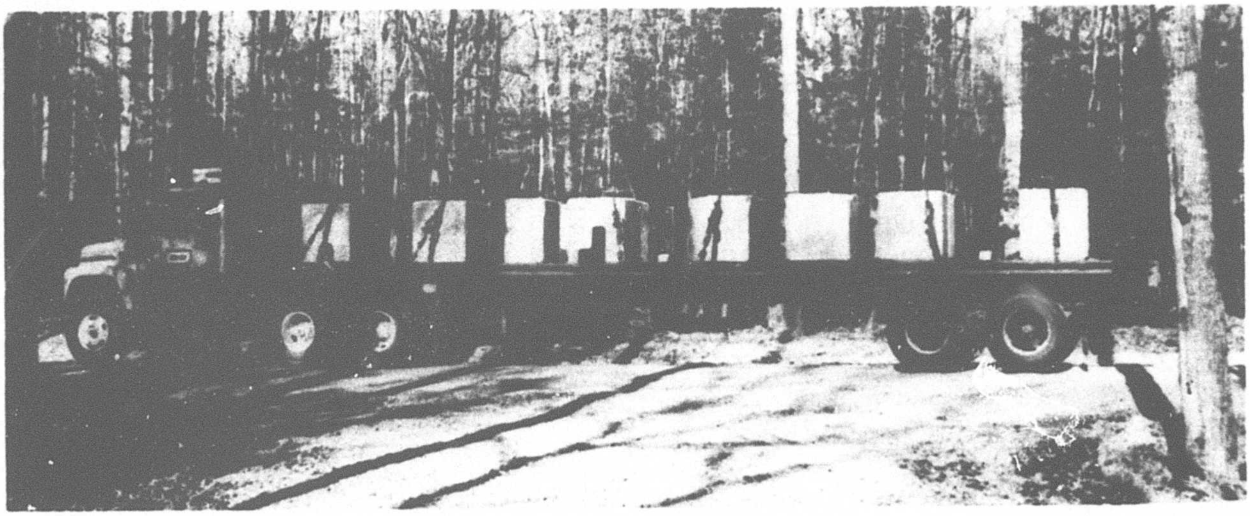


Figure 2. Truck Type II With Full Load.

Truck Type III

1973 truck-tractor-semitrailer combination: two-axle tractor, one-axle, 30-foot, flatbed, semitrailer, Figure 3.

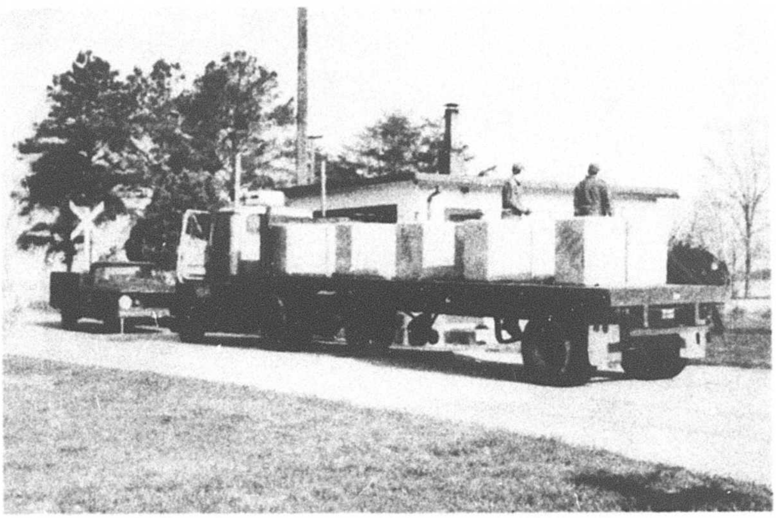


Figure 3. Truck Type III With Full Load.

STATIC TEST

The test trucks delivered to Fort Eustis by the leasing agency were inspected for structural defects before acceptance by the project test officer.

Static testing started for each truck with loading concrete blocks on the cargo bed in the positions that would be maintained throughout all phases of the static and dynamic tests. Truck axle weights were recorded from empty to full load for each increment load pattern. Each concrete block was weighed and the weight stenciled on the block for identification throughout the tests. The physical dimensions of the truck were measured and used along with the block weights to calculate wheel-to-surface vertical force reactions using moments about an axle.

The purpose of the static test was to develop the spring rates of tires, suspension system, and cargo bed bending for each of the test vehicles. The trucks were repeatedly loaded and unloaded in increments of the limit load value, while vertical deflection measurements were recorded for the tires, springs, and cargo bed. Tire pressures were changed to determine the effect of changes in the practical range on the combined spring rate.

The loads, converted to single-axle loads in pounds versus the combined vertical deflection in inches of all tires and springs on an axle, defined the spring constants.

It was anticipated that a procedure could be developed for relating these spring constants to the dynamic ride characteristics of the test vehicles.

The following test procedure for the three vehicles was used:

1. Static testing of the vehicles was conducted on a large, paved area. Each truck was parked on the same general surface so that static physical measurements for each cargo bed could be measured from a common base.

2. The blocks were removed in equal weight increments until all the load had been removed from the vehicle.

3. The vehicle was then reloaded in the same weight increments, completing one unloading and loading cycle. Figure 4 illustrates the unloading and loading cycles followed for truck Type II at the various tire pressures.

4. Vertical deflection measurements were made at the front and rear axles and center of the load.

The following information was recorded for each test vehicle. (Tire, spring, and frame deflection measurements were repeated for each loading cycle):

1. The payload and tire pressure.

2. The location of the axles, loads, center of payload, and fifth wheel for the truck and truck-tractor-semitrailer combinations.

3. Vertical distance from the pavement to the rear axle of two-axle truck-tractors and semitrailers at the longitudinal center line of the vehicles (tire deflections) (Figure 5).

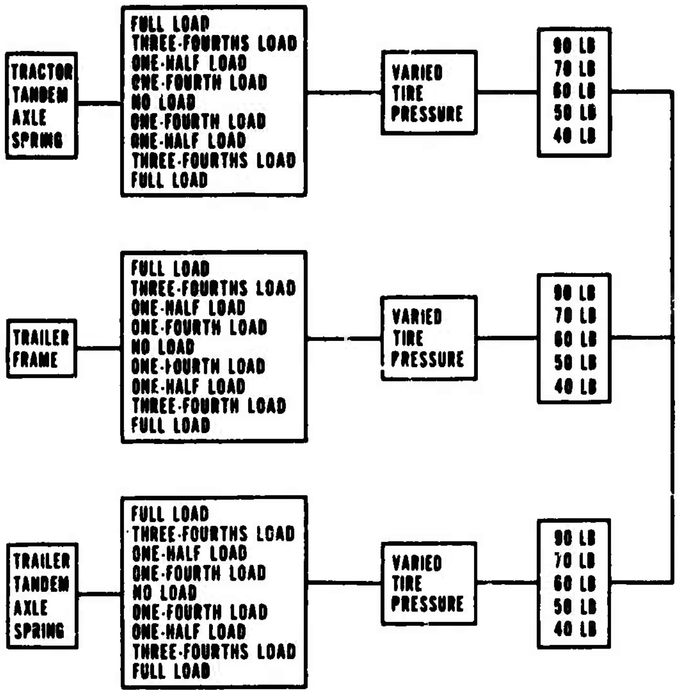


Figure 4. Static Test Procedure for Truck Type II.

4. The vertical distance from the pavement to a point on the frame above the truck or tractor and semitrailer rear springs and directly over the axles at the longitudinal center line of the vehicle (combined tire and spring deflections for truck or truck-tractor-semitrailer combination).

5. The vertical distance from the pavement to a point on the frame of the vehicle at the center of the payload (combined tire, spring, and frame deflection at center of the payload) (Figure 6).

From the results of the static tests, a spring constant was determined based on the combined vertical deflection of the tires and the suspension system for each of the single-axle or tandem-axle units on the truck and truck-tractors and semitrailers. All spring constants, hereafter called payload spring rates, are based on single-axle payloads.

TEST SITE

The truck dynamic test runs were conducted on a Fort Eustis, Virginia, secondary gravel road extending parallel to Bailey Creek for 0.9 mile through an isolated area in the northwest section of the reservation (Figures 7 and 8).

Fort Eustis Facilities Engineering surface-graded the road, prepared truck bypasses and turnarounds, installed the steel pipe and concrete bumps, and, in general, completely reworked the on-post secondary road into an excellent cargo truck dynamic test site.

Because the requirement was to produce and repeat constant shock forces into the cargo bed of the test vehicles over a series of set runs, it was necessary to construct standard, uniform bumps on the test road.

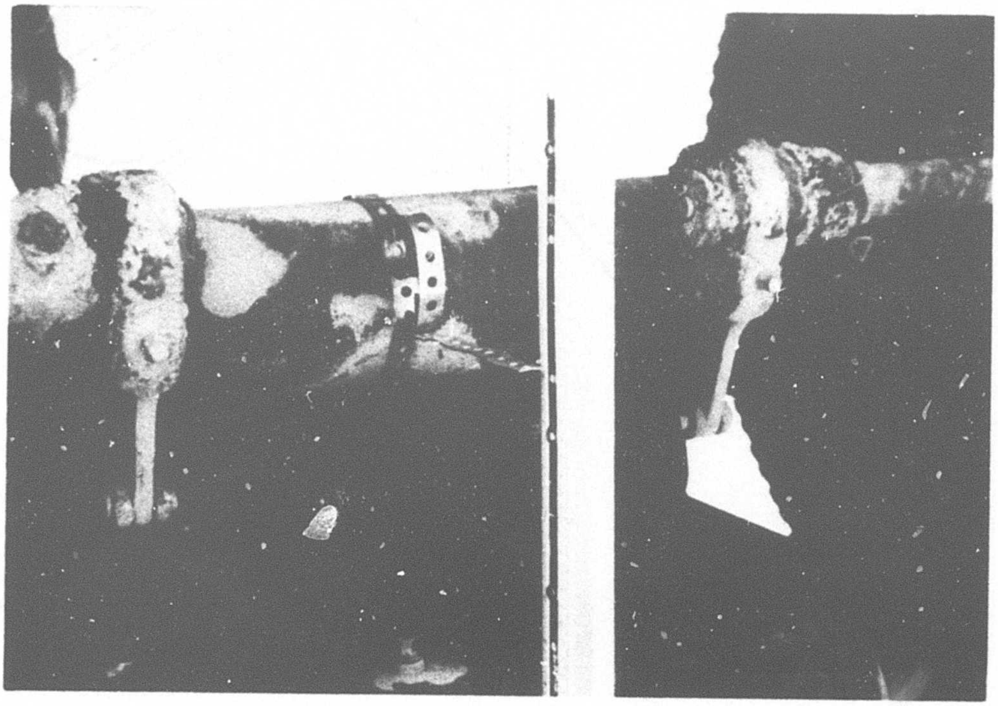


Figure 5. Measurement of Tire Deflection. Static Test.

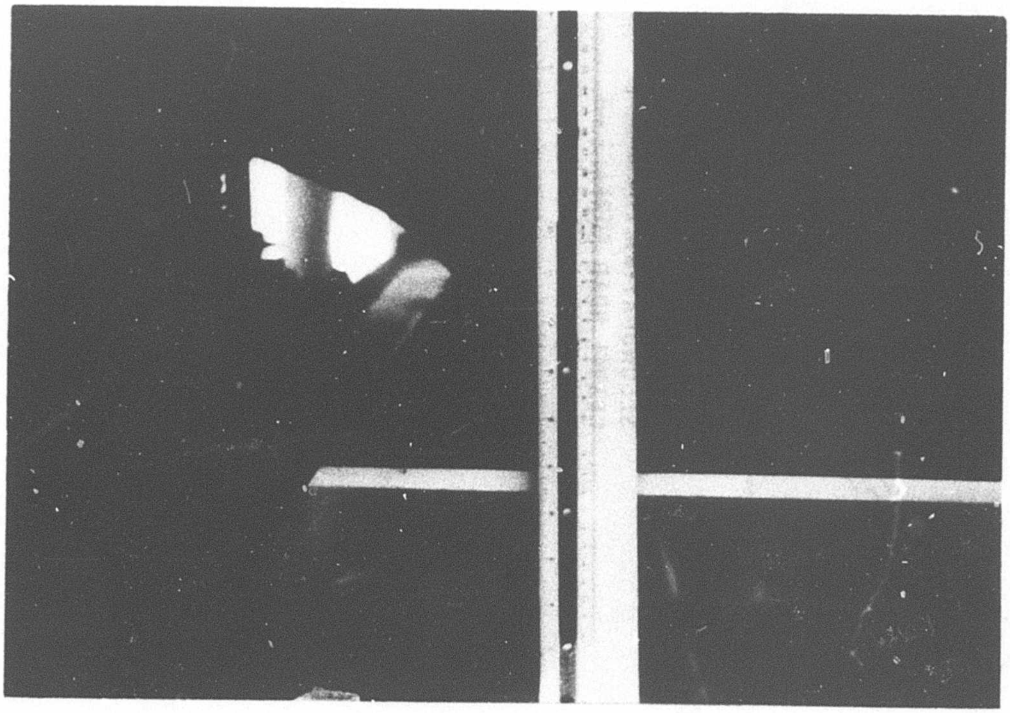


Figure 6. Measurement of Truck Frame Deflection, Static Test.

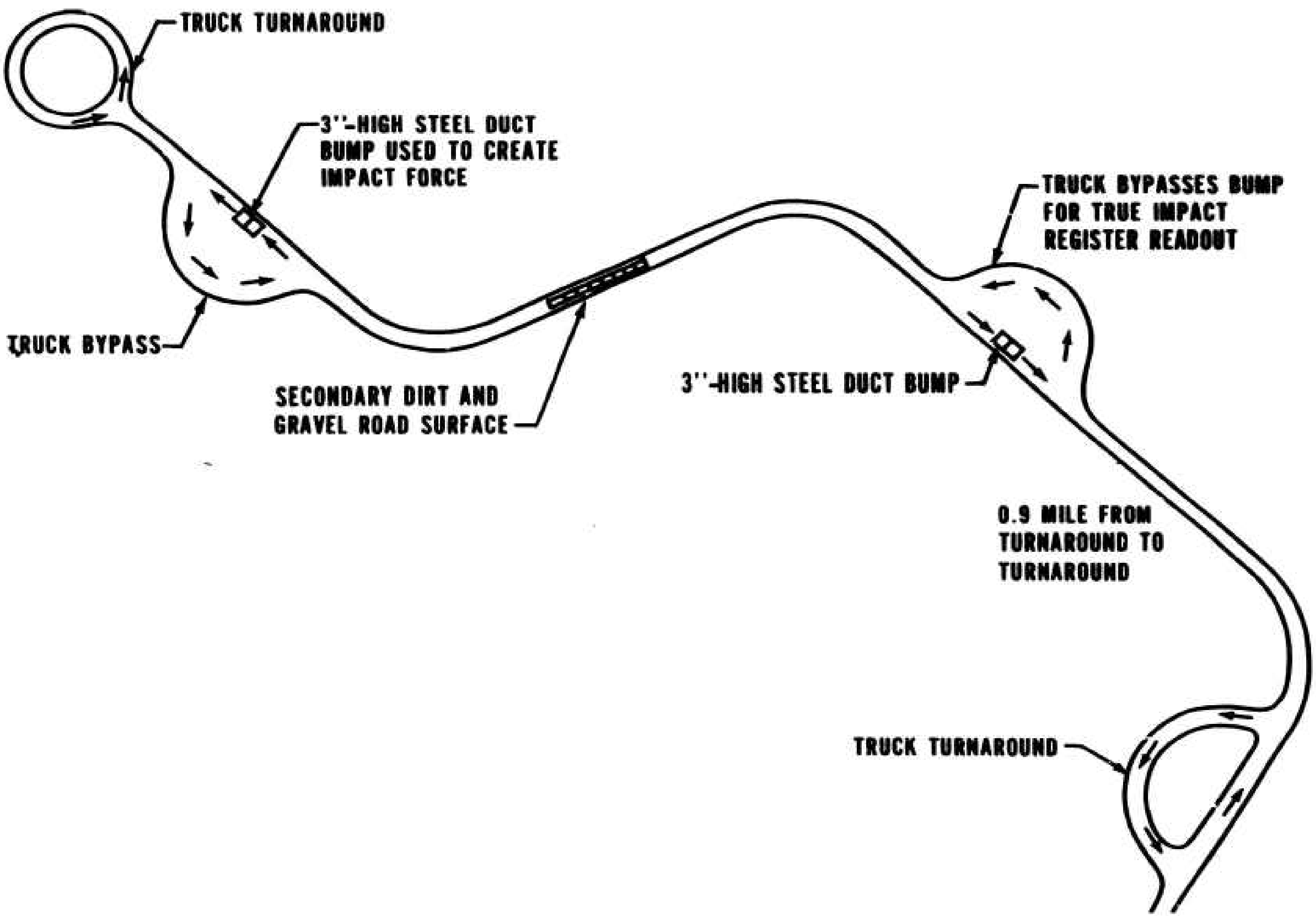


Figure 7. Dynamic Test Site, Fort Eustis, Virginia.

Ten-inch-diameter steel ducts were embedded in separate concrete foundations at the far ends of the test run, so that the large vehicles could obtain a maximum steady speed before passing over the bumps. Three inches of the steel duct were left protruding across the width of the concrete pads (Figure 9). The steel duct, jutting up from a flat foundation, provided 12 feet of uniform bump along the longitudinal axis of the pipe and, lying perpendicular to the direction of travel, exerted an impact force on the truck tires as they passed over the duct. The bumps produced the desired impact force into the truck bed through the tires and springs.

INSTRUMENTATION

Three Impact Register Company, RM-3W Mechanical Accelerometers, Figure 10, were used to record shock values delivered to the bed of the cargo trucks. The accelerometers were securly fastened to the cargo beds of the trucks in three locations. On the 18-foot flatbed truck Type I, they were located at the following positions: the first register was placed aft of the bulkhead, the second register was placed midspan on the bed between the forward accelerometer location and the rear axle, and the third register was placed over the rear axle. On both truck-tractor-semitrailer combinations, the forward accelerometer was placed over the 5th wheel, the aft accelerometer was anchored midway over the trailer axle(s), and the middle register was placed at one-half the distance from the 5th wheel to the rear trailer axle(s).

The three individual units gave accurate readings to within 6 percent of full-scale deflection. To obtain factual readings over the anticipated g range, the instruments were calibrated by the manufacturers to within 2 percent of full scale just prior to testing.

Each accelerometer recorded a permanent, legible record on wax-coated strip charts of the vertical, lateral, and longitudinal g impact forces sensed at the three surface locations where the instruments are attached to the truck bed.

Within the accelerometer, the three-way data chart is driven by a spring-powered, 30-day clock motor that rotates the recording paper around an actuating roller. Data are registered on the wax-coated surface by a stylus exerting pressure on the paper; the paper was advanced after the test vehicle had traversed the bump so that the marks made by the stylus could be separated.

The accelerometers recorded directly in g forces. Ranges set for the three-way recorders were $\pm$10g vertically, $\pm$5g laterally, and $\pm$15g longitudinally. Only the longest side of the stylus printout was read as the shock value; only

Figure 8. Dynamic Test Course.

Figure 9. Standard 3-Inch Bump, Dynamic Test Course.

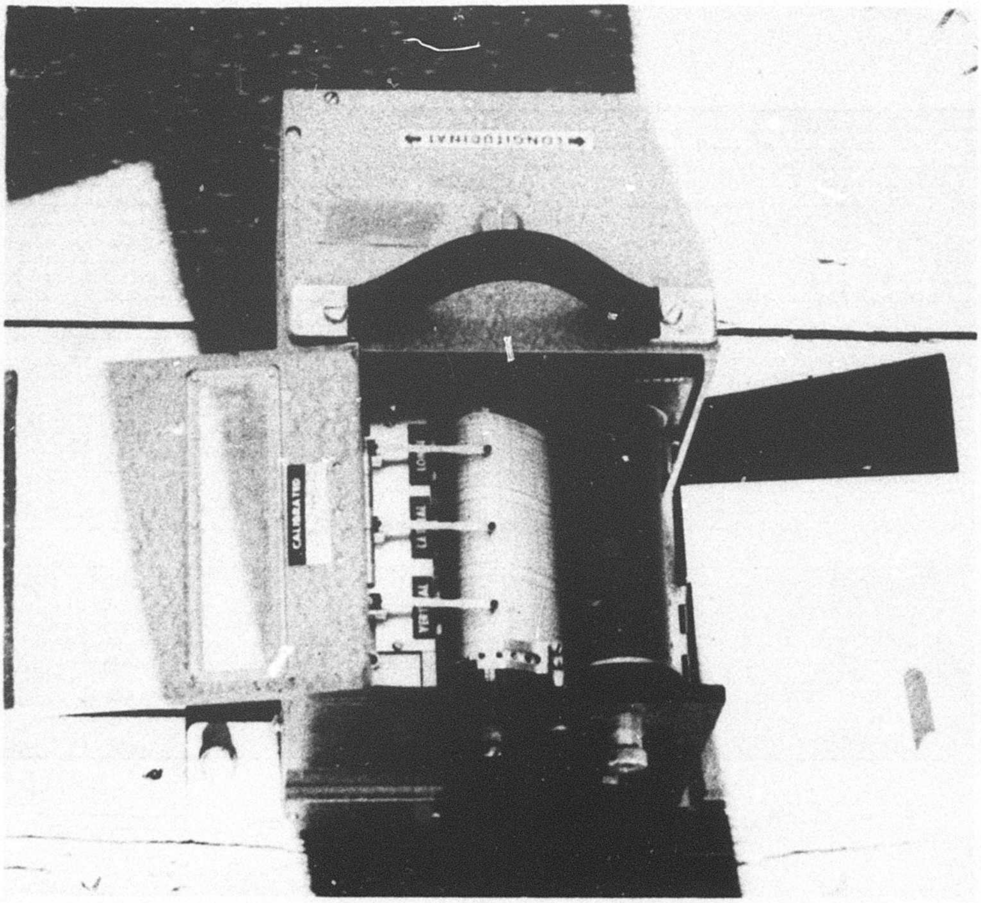


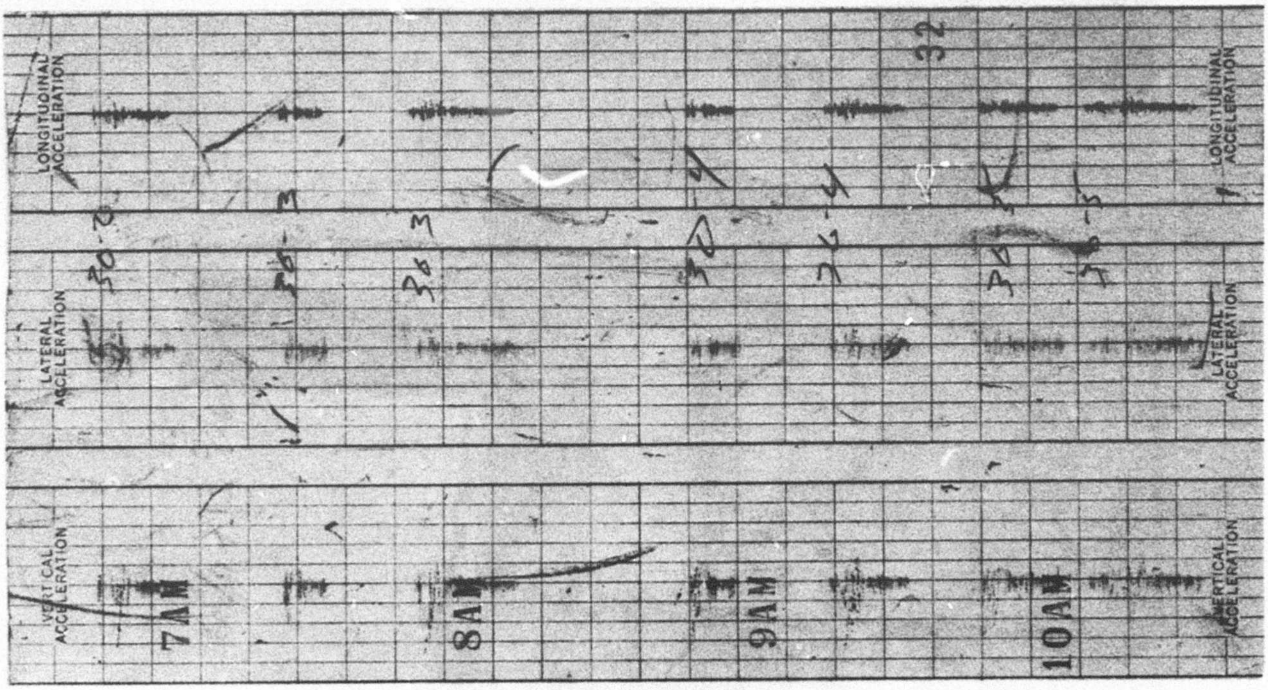
Figure 10. Impact Register Bolted to Cargo Bed.

vertical forces were considered as a serious source of potential cargo damage and were therefore used for formulating the shock index. The vertical axis indicates the amount of up-and-down force transmitted to the cargo. This force is severe when one considers that the cargo can leave the truck bed for any force in excess of 1g.

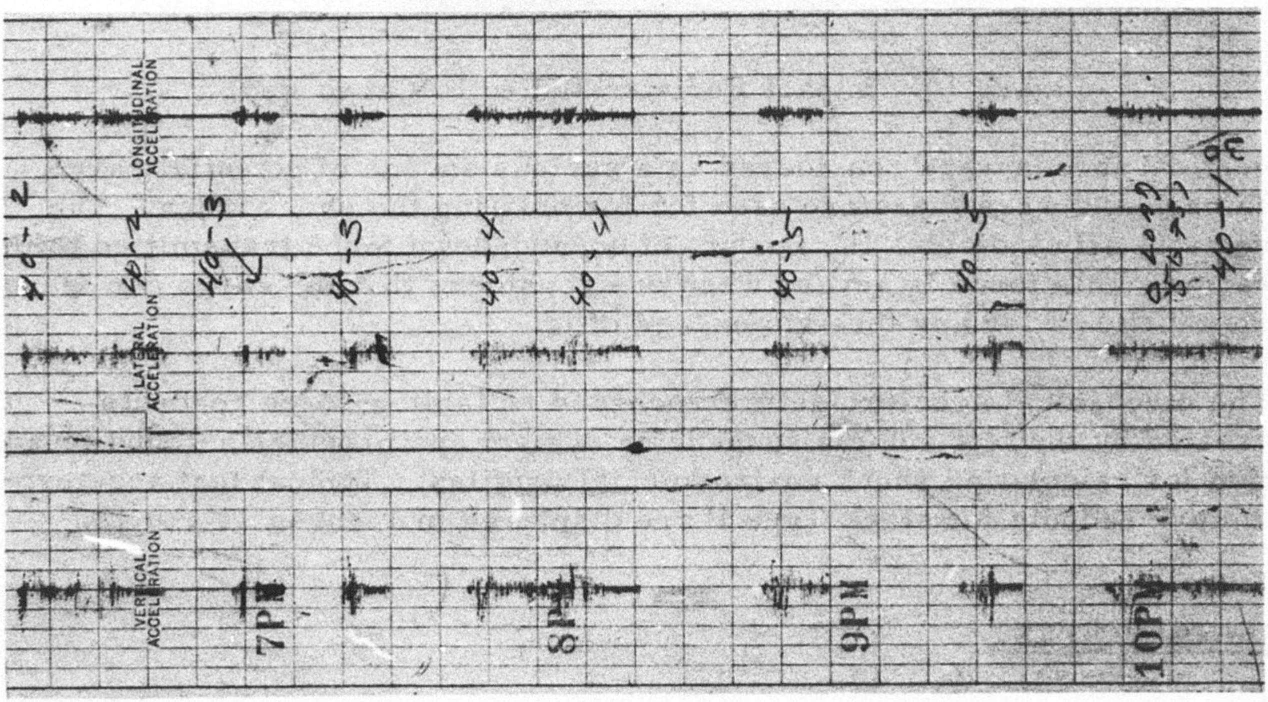
The mechanical accelerometers recorded reliable g-force readouts created by the test vehicle suspension system and provided a sound foundation for calculating shock environmental profiles. Typical test accelerometer readouts for truck Type II are displayed in Figures 11 and 12.

DYNAMIC TEST

The purpose of the dynamic test was to measure the impact forces transmitted from the two 3-inch bumps on the test course through the tires and suspension system into the cargo bed of the test vehicles. The payloads, tire pressures, and speeds of the trucks were varied to determine trends in the impact forces.

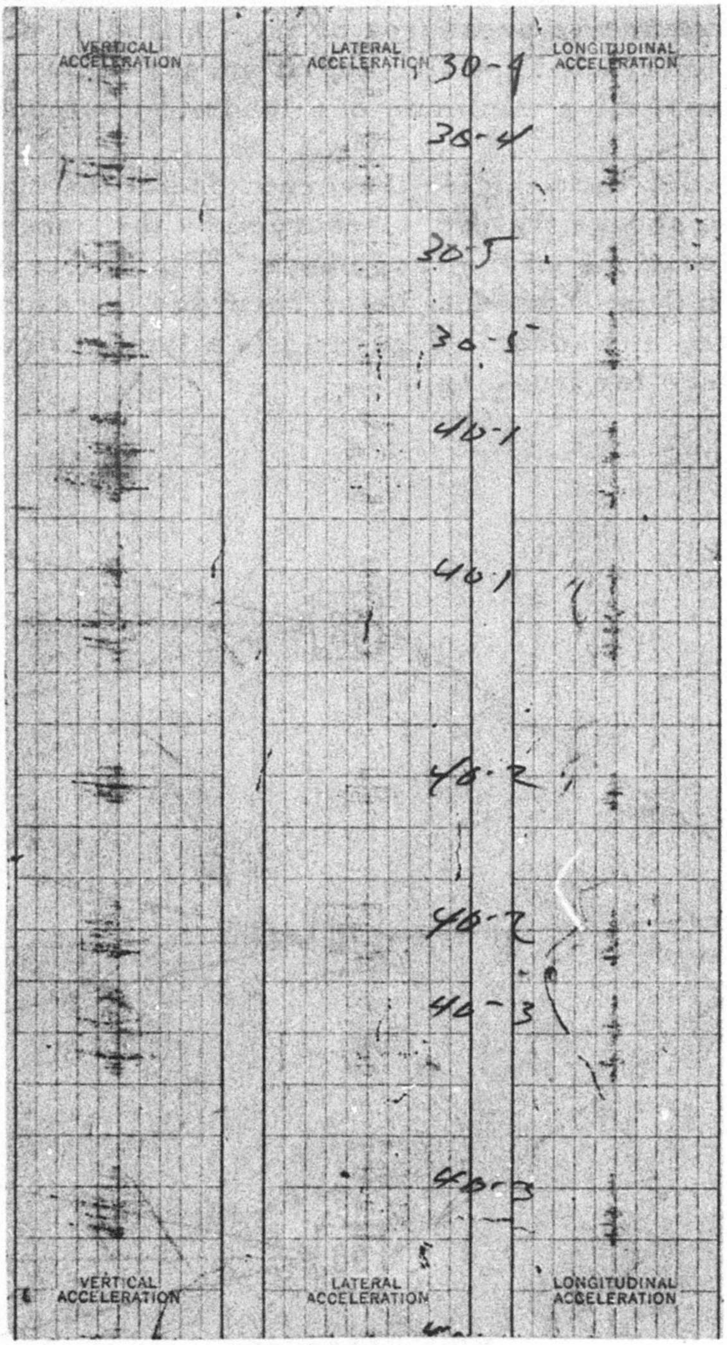


Forward Accelerometer Trace



Midaccelerometer Trace

Figure 11. Typical Accelerometer Readouts for Truck Type II.



Rear Accelerometer Trace

Figure 12. Typical Accelerometer Readout for Truck Type II.

The following describes dynamic test procedures:

A set of 5 runs (10 runs for truck Type I) were made in both directions over the test course at tire pressures of 50, 70, and 90 pounds per square inch (psi) (70 psi for truck Type III); and at speeds of 20, 30, and 40 miles per hour (mph) for a minimum of 6 loads (8 for truck Type II).

On each one-way run, the vehicles traversed one of the standard 3-inch bumps resulting in shocks that were recorded by the impact registers at their respective locations on the cargo beds. These sets of runs resulted in 10 (20 for truck Type I) impacts being recorded for each load configuration, tire pressure, and speed. Figure 13 is a typical flow chart of the dynamic testing used for truck Type II.

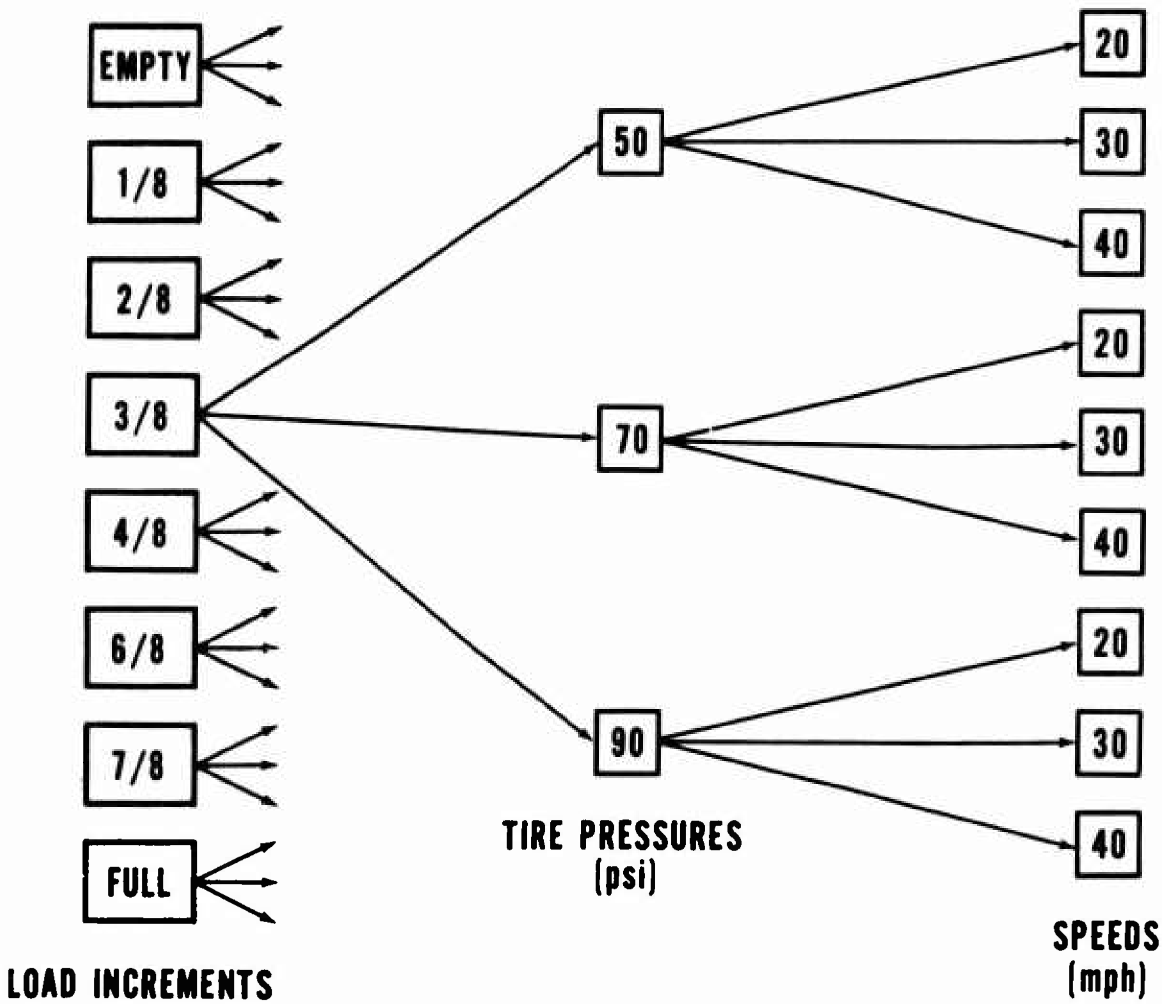


Figure 13. Flow Chart of Typical Truck Type II Dynamic Test Procedure.

VI. ANALYSIS OF DATA

Data collected from the static and dynamic tests performed on truck Type II are analyzed in detail in the following chapter. Results from tests on truck Types I and III, which are similar to Type II, are presented in Appendixes A and B.

STATIC TEST DATA AND RESULTS

Data collected from the static tests were used to determine the payload axle loads and the payload axle spring rates (K) of each of the test vehicles.

Calculation of the payload axle load involved a simple summation of bending moments about the convenient axle. Figures 14 through 21 illustrate the various loading configurations for truck Type II; Figure 22 shows the basic truck dimensions. Tabulation of the payload axle loads for truck Type II is shown on Table II.

The measured vertical deflections of the tires (axles) and the suspension system during the unloading and loading cycles for truck Type II are listed in Tables III through VII. The average of the 10 combined tire-spring deflections, 5 unloading and 5 loading cycles, was computed and plotted against their respective payload axle loads, as shown in Figure 23 and 24. The payload axle spring rate for each single or tandem axle unit (K in pounds per inch deflection) is the slope of the line plotted.

DYNAMIC TEST DATA AND RESULTS

The impact forces transmitted from the bumps to the cargo bed were measured in the dynamic tests. The dynamic testing procedures used for truck Type II is presented in Table VIII. Basically, the procedure was to vary the truck speed at certain tire pressures and loading configuration. Thus, any one of the variables could be examined in light of the other two.

Figure 25 illustrates the typical trend in the impact forces as a result of increasing the speed of the test vehicles. A vehicle speed of 30 miles per hour produced the lowest impact forces for these test vehicles.

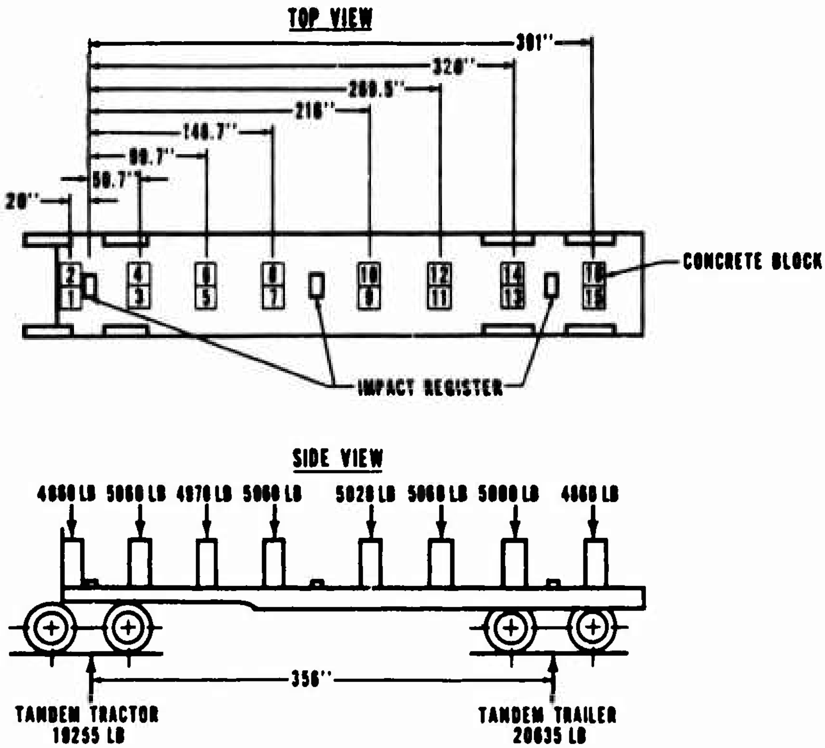


Figure 14. Static Test, Full Load, Truck Type II.

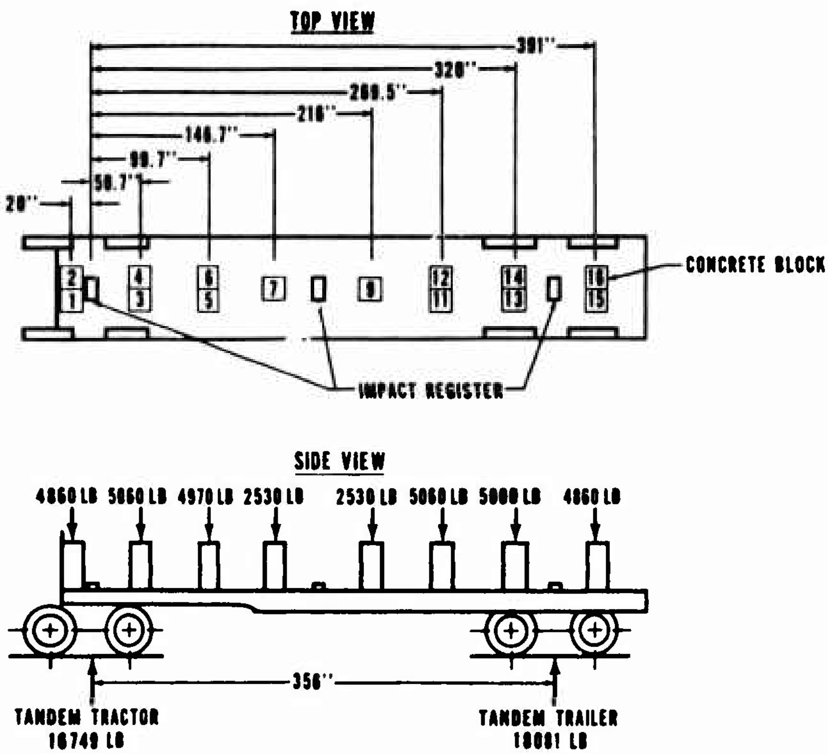


Figure 15. Static Test, Seven-Eighths Load, Truck Type II.

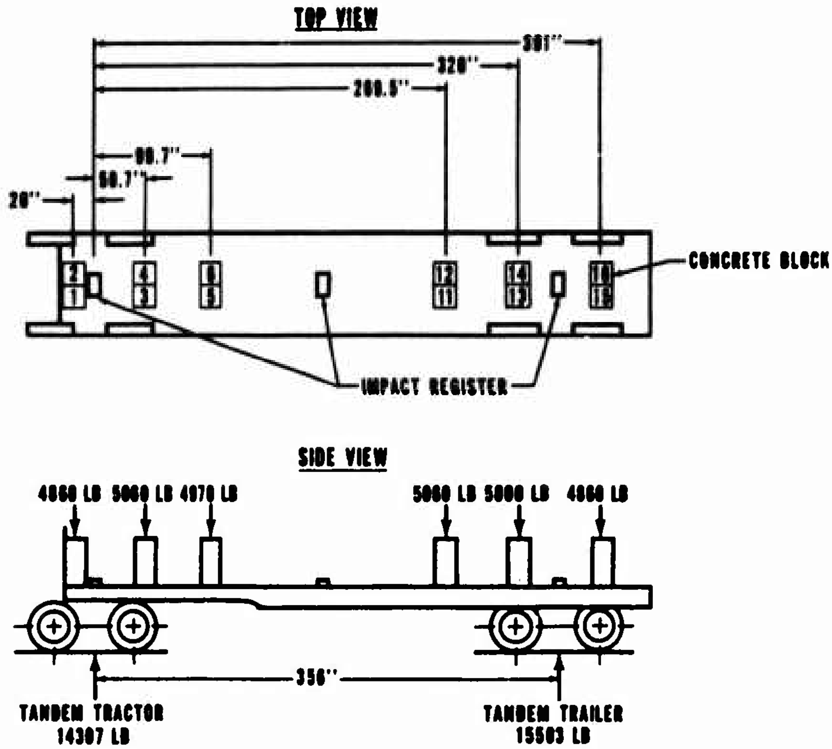


Figure 16. Static Test, Three-Fourths Load, Truck Type II.

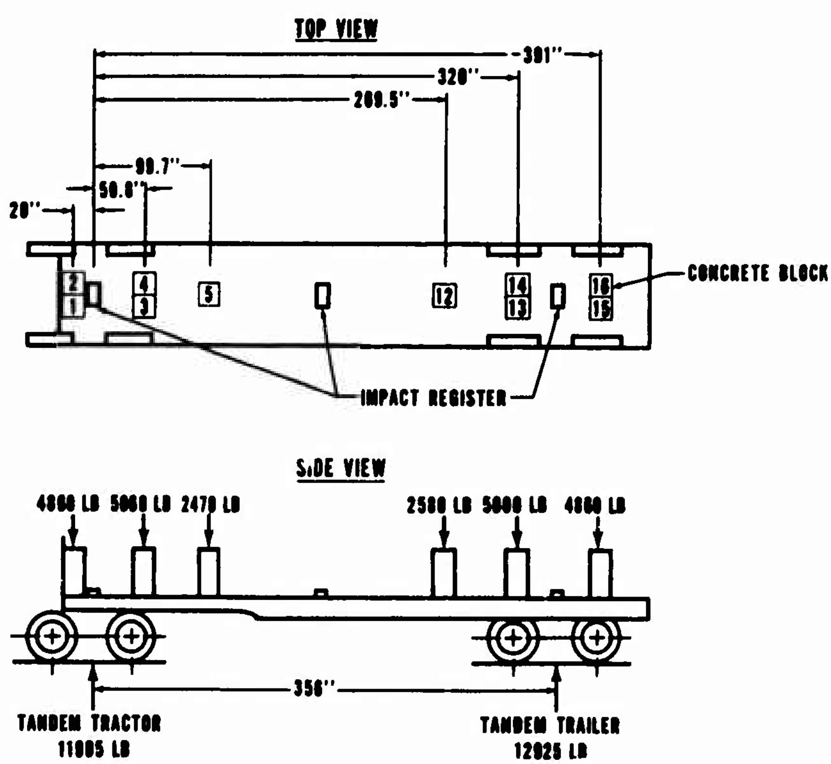


Figure 17. Static Test, Five-Eighths Load, Truck Type II.

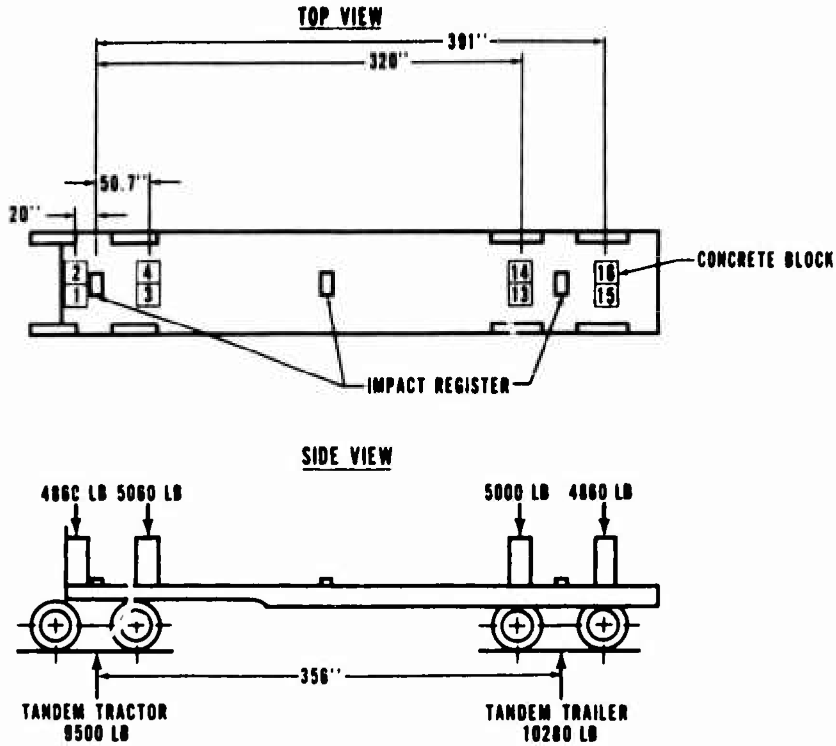


Figure 18. Static Test, One-Half Load, Truck Type II.

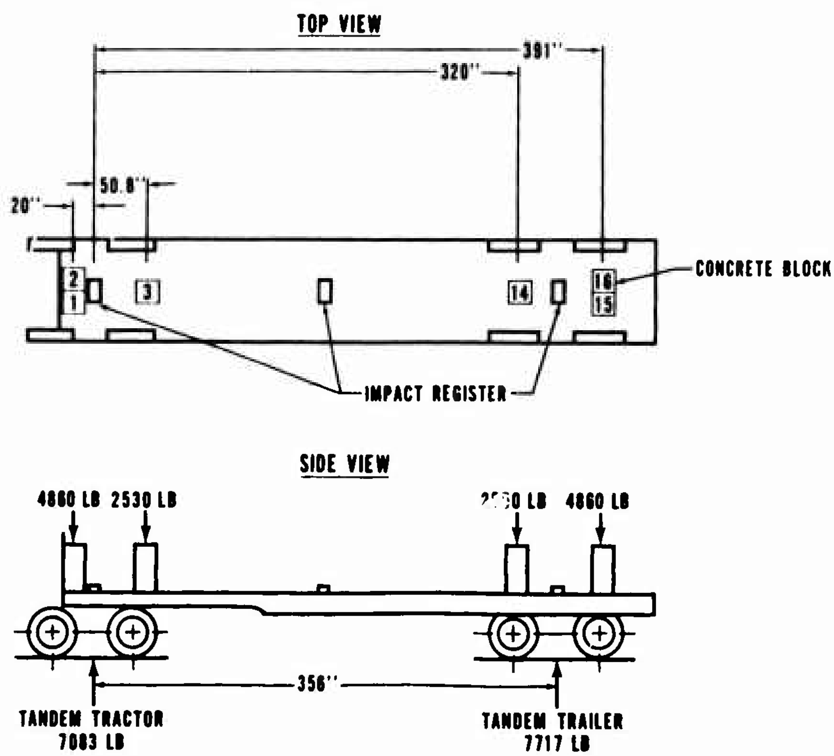


Figure 19. Static Test, Three-Eighths Load, Truck Type II.

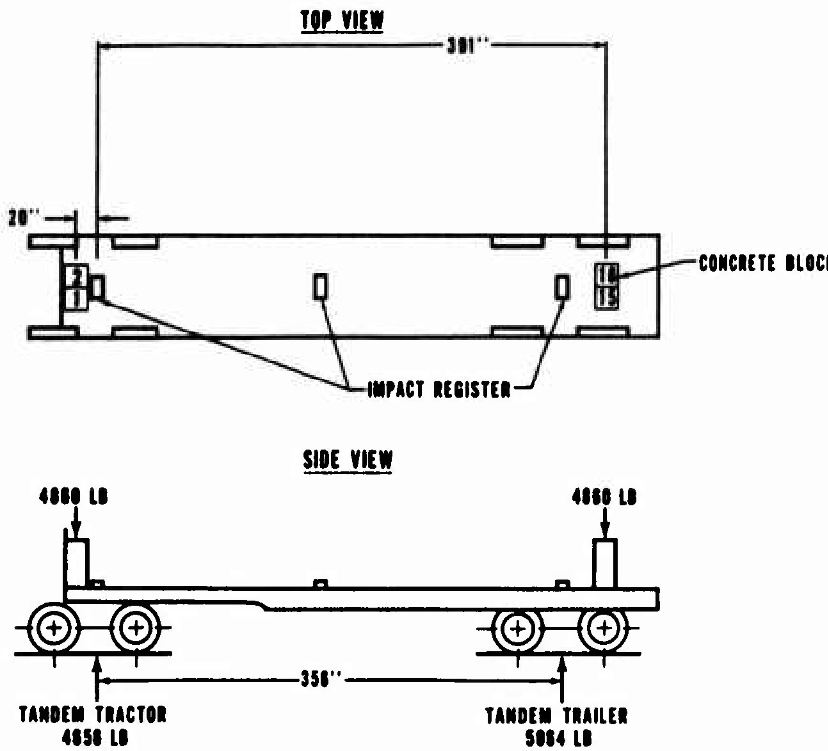


Figure 20. Static Test, One-Fourth Load, Truck Type II.

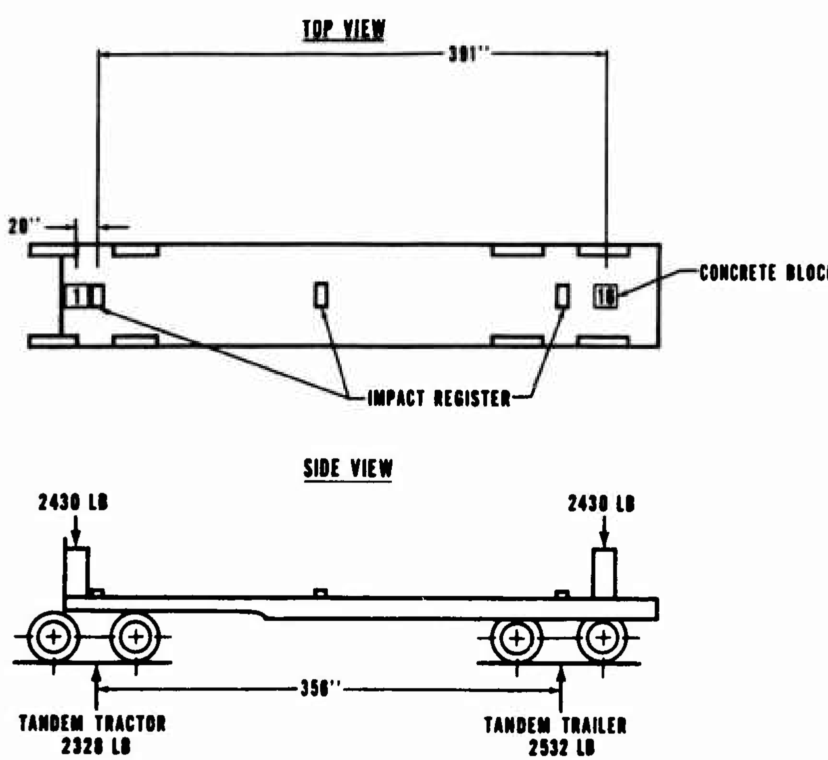


Figure 21. Static Test, One-Eighth Load, Truck Type II.

VEHICLE EMPTY

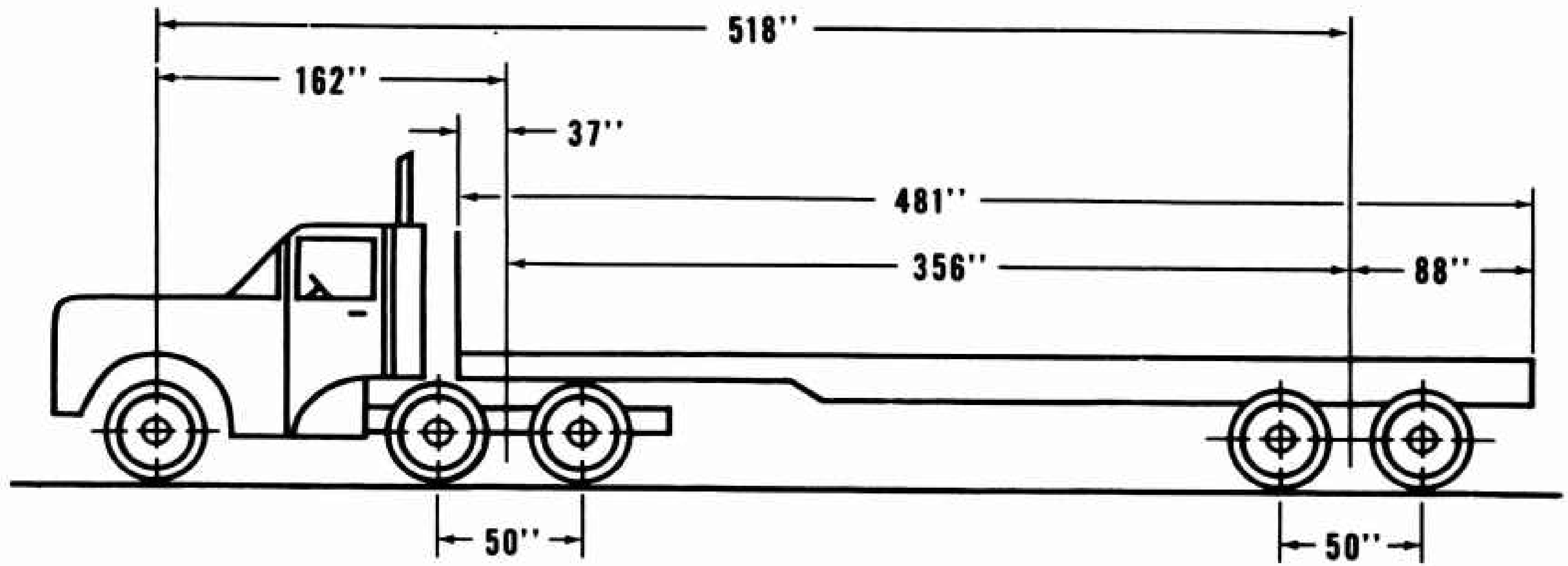


Figure 22. Basic Truck Dimensions, Truck Type II.

TABLE II

TRUCK TYPE II, PAYLOAD AXLE LOADS, STATIC AND DYNAMIC TESTS

Full Load		7/8 Load		3/4 Load		5/8 Load		1/2 Load		3/8 Load		1/4 Load		1/8 Load	
Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)
1	2,430	1	2,430	1	2,430	1	2,430	1	2,430	1	2,430	1	2,430	1	2,430
2	2,430	2	2,430	2	2,430	2	2,430	2	2,430	2	2,430	2	2,430		
3	2,530	3	2,530	3	2,530	3	2,530	3	2,530	3	2,530				
4	2,530	4	2,530	4	2,530	4	2,530	4	2,530						
5	2,470	5	2,470	5	2,470	5	2,470								
6	2,500	6	2,500	6	2,500										
7	2,530														
8	2,530	8	2,530												
9	2,530														
10	2,490	10	2,490												
11	2,480	11	2,480	11	2,480										
12	2,580	12	2,580	12	2,580	12	2,580								
13	2,450	13	2,450	13	2,450	13	2,450	13	2,450						
14	2,550	14	2,550	14	2,550	14	2,550	14	2,550	14	2,550				
15	2,430	15	2,430	15	2,430	15	2,430	15	2,430	15	2,430	15	2,430		
16	2,430	16	2,430	16	2,430	16	2,430	16	2,430	16	2,430	16	2,430	16	2,430
	39,890		34,830		29,810		24,830		19,780		14,800		9,720		4,860
Single Axle Payloads (lb)															
Tandem Tractor	Tandem Trailer	Tandem Tractor	Tandem Trailer	Tandem Tractor	Tandem Trailer	Tandem Tractor	Tandem Trailer	Tandem Tractor	Tandem Trailer	Tandem Tractor	Tandem Trailer	Tandem Tractor	Tandem Trailer	Tandem Tractor	Tandem Trailer
9,627	10,317	8,374	9,040	7,403	7,751	5,952	6,462	4,750	5,140	3,541	3,858	2,328	2,532	1,169	1,266

TABLE III

TRUCK TYPE II, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 90 PSI TIRE PRESSURE

	Static Measurements					Static Deflections					
Block No.	Load (lb)	Tractor Springs (in.)	Tractor Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Tractor Springs (in.)	Tractor Tires (in.)	Tractor Springs and Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Trailer Springs and Tires (in.)
1 - 16	Full (39,890)	1.500	3.000	2.000	4.875	0.500	0.438	0.938	0.688	0.500	1.188
1 - 6, 11 - 16	3/4 (29,810)	1.500	2.906	1.750	5.032	0.500	0.344	0.844	0.595	0.343	0.938
1 - 4, 13 - 16	1/2 (19,780)	1.437	2.781	1.500	5.125	0.437	0.219	0.656	0.438	0.250	0.688
1, 2, 15, 16	1/4 (9,720)	1.312	2.687	1.156	5.250	0.312	0.125	0.437	0.219	0.125	0.344
0	0	1.000	2.562	0.812	5.375	0.000	0.000	0.000	0.000	0.000	0.000
1, 2, 15, 16	1/4 (9,720)	1.062	2.656	1.032	5.250	0.062	0.094	0.156	0.095	0.125	0.220
1 - 4, 13 - 16	1/2 (19,780)	1.218	2.781	1.312	5.125	0.218	0.219	0.437	0.250	0.250	0.500
1 - 6, 11 - 16	3/4 (29,810)	1.281	2.875	1.593	5.016	0.218	0.313	0.531	0.422	0.359	0.781
1 - 16	Full (39,890)	1.375	3.093	1.875	4.875	0.375	0.531	0.906	0.563	0.500	1.063

TABLE IV

TRUCK TYPE II, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 70 PSI TIRE PRESSURE

Block No.	Static Measurements					Static Deflections					
	Load (lb)	Tractor Springs (in.)	Tractor Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Tractor Springs (in.)	Tractor Tires (in.)	Tractor Springs and Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Trailer Springs and Tires (in.)
1 - 16	Full (39,890)	1.500	2.000	3.625	5.062	0.500	0.469	0.969	0.688	0.500	1.188
1 - 6, 11 - 16	3/4 (29,810)	1.468	1.906	3.437	5.218	0.468	0.375	0.843	0.656	0.344	1.000
1 - 4, 13 - 16	1/2 (19,780)	1.437	1.781	3.156	5.312	0.437	0.250	0.687	0.469	0.250	0.719
1, 2, 15, 16	1/4 (9,720)	1.281	1.687	2.812	5.500	0.281	0.156	0.437	0.313	0.062	0.375
0	0	1.000	1.531	2.437	5.562	0.000	0.000	0.000	0.000	0.000	0.000
1, 2, 15, 16	1/4 (9,720)	1.156	1.656	2.687	5.437	0.156	0.125	0.281	0.125	0.125	0.250
1 - 4, 13 - 16	1/2 (19,780)	1.218	1.750	2.968	5.312	0.218	0.219	0.437	0.281	0.250	0.531
1 - 6, 11 - 16	3/4 (29,810)	1.250	1.875	3.250	5.156	0.250	0.344	0.594	0.407	0.406	0.813
1 - 16	Full (39,890)	1.312	2.000	3.562	5.032	0.312	0.469	0.781	0.595	0.530	1.125

TABLE V

TRUCK TYPE II, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 60 PSI TIRE PRESSURE

Block No.	Static Measurements					Static Deflections					
	Load (lb)	Tractor Springs (in.)	Tractor Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Tractor Springs (in.)	Tractor Tires (in.)	Tractor Springs and Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Trailer Springs and Tires (in.)
1 - 16	Full (39,890)	1.500	3.500	3.125	5.750	0.500	0.468	0.968	0.657	0.531	1.188
1 - 6, 11 - 16	3/4 (29,810)	1.500	3.406	2.937	5.812	0.500	0.374	0.874	0.531	0.469	1.000
1 - 4, 13 - 16	1/2 (19,780)	1.437	3.281	2.625	5.937	0.437	0.249	0.686	0.344	0.344	0.688
1, 2, 15, 16	1/4 (9,720)	1.312	3.156	2.281	6.125	0.312	0.124	0.436	0.188	0.156	0.344
0	0	1.562	3.032	1.937	6.281	0.000	0.000	0.000	0.000	0.000	0.000
1, 2, 15, 16	1/4 (9,720)	1.093	3.125	2.281	6.062	0.093	0.093	0.186	0.125	0.219	0.344
1 - 4, 13 - 16	1/2 (19,780)	1.093	3.250	2.437	6.000	0.093	0.218	0.311	0.219	0.281	0.500
1 - 6, 11 - 16	3/4 (29,810)	1.250	3.375	2.750	5.875	0.250	0.343	0.593	0.407	0.406	0.813
1 - 16	Full (39,890)	1.343	3.500	3.000	5.750	0.343	0.468	0.811	0.532	0.531	1.063

TABLE VI

TRUCK TYPE II, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 50 PSI TIRE PRESSURE

	Static Measurements					Static Deflections					
Block No.	Load (lb)	Tractor Springs (in.)	Tractor Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Tractor Springs (in.)	Tractor Tires (in.)	Tractor Springs and Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Trailer Springs and Tires (in.)
1 - 16	Full (39,890)	1.343	3.625	3.187	5.593	0.375	0.563	0.938	0.656	0.563	1.219
1 - 6, 11 - 16	3/4 (29,810)	1.312	3.500	2.937	5.750	0.344	0.438	0.782	0.563	0.406	0.969
1 - 4, 13 - 16	1/2 (19,780)	1.312	3.375	2.687	5.875	0.344	0.313	0.657	0.438	0.281	0.719
1, 2, 15, 16	1/4 (9,720)	1.250	3.218	2.375	6.062	0.282	0.156	0.438	0.313	0.094	0.407
0	0	0.968	3.062	1.968	6.156	0.000	0.000	0.000	0.000	0.000	0.000
1, 2, 15, 16	1/4 (9,720)	1.093	3.187	2.218	6.032	0.125	0.125	0.250	0.126	0.124	0.250
1 - 4, 13 - 16	1/2 (19,780)	1.187	3.312	2.531	5.875	0.219	0.250	0.469	0.282	0.281	0.563
1 - 6, 11 - 16	3/4 (29,810)	1.218	3.437	2.906	5.750	0.250	0.375	0.625	0.532	0.406	0.938
1 - 16	Full (39,890)	1.281	3.593	3.187	5.593	0.313	0.531	0.844	0.656	0.563	1.219

TABLE VII

TRUCK TYPE II, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 40 PSI TIRE PRESSURE

	Static Measurements					Static Deflections					
Block No.	Load (lb)	Tractor Springs (in.)	Tractor Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Tractor Springs (in.)	Tractor Tires (in.)	Tractor Springs and Tires (in.)	Trailer Springs (in.)	Trailer Tires (in.)	Trailer Springs and Tires (in.)
1 - 16	Full (39,890)	1.281	3.750	3.375	5.406	0.313	0.594	0.907	0.595	0.687	1.282
1 - 6, 11 - 16	3/4 (29,810)	1.250	3.625	3.156	5.593	0.282	0.469	0.751	0.563	0.500	1.063
1 - 4, 13 - 16	1/2 (19,780)	1.250	3.500	2.812	5.750	0.282	0.344	0.626	0.376	0.343	0.719
1, 2, 15, 16	1/4 (9,720)	1.218	3.343	2.531	5.906	0.250	0.187	0.437	0.251	0.187	0.438
0	0	0.968	3.156	2.093	6.093	0.000	0.000	0.000	0.000	0.000	0.000
1, 2, 15, 16	1/4 (9,720)	1.062	3.281	2.312	5.937	0.094	0.125	0.219	0.063	0.156	0.219
1 - 4, 13 - 16	1/2 (19,780)	1.156	3.437	2.656	5.750	0.188	0.281	0.469	0.220	0.343	0.563
1 - 6, 11 - 16	3/4 (29,810)	1.250	3.625	3.093	5.562	0.282	0.469	0.751	0.469	0.531	1.000
1 - 16	Full (39,890)	1.312	3.781	3.406	5.375	0.344	0.625	0.969	0.595	0.718	1.313

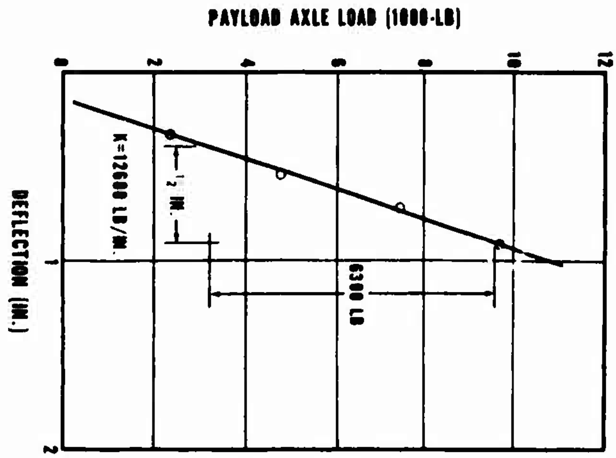


Figure 23. Payload Axle Spring Rate for Tractor Axle on Truck Type II.

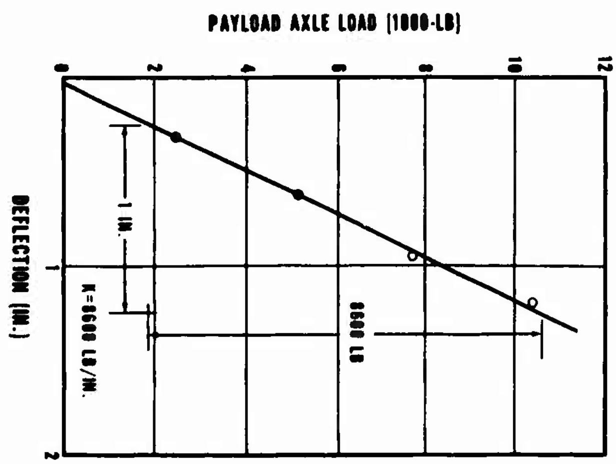


Figure 24. Payload Axle Spring Rate for Trailer Axle on Truck Type II.

TABLE VIII
TRUCK TYPE II, DYNAMIC LOADING AND OPERATIONAL TEST PROCEDURE

Tire Pressure (90, 70, and 50 lb)										
Impact Register Location	Speed (mph)	Load Increment								
Over 5th Wheel	20, 30, 40	Full	7/8	3/4	5/8	1/2	3/8	1/4	1/8	0
Midspan Between 5th Wheel and Semitrailer Tandem	20, 30, 40	Full	7/8	3/4	5/8	1/2	3/8	1/4	1/8	0
Over Semitrailer Tandem	20, 30, 40	Full	7/8	3/4	5/8	1/2	3/8	1/4	1/8	0

NOTES:
The variable load and dynamic test conditions were imposed on the vehicle for five complete circuits of the road course.

Variables:

Three - Tire pressure (90, 70, and 50 lb)
Nine - Load increments (Full, 7/8, 3/4, 5/8, 1/2, 3/8, 1/4, 1/8, 0)
Three - Speeds (20, 30, and 40 mph)

There were 2,430 readings for three recorders.

Figure 26 shows the variation of the impact forces with increasing tire pressure. In general, increasing the tire pressure results in larger impact forces transmitted to the cargo bed. Figure 27 shows how the payload axle load affects the impact forces. The middle range of axle loads produced the lower impact forces, whereas the light or heavy loads produced the higher impact forces. These results are typical of the impact forces recorded over the axles of all three test vehicles.

Close examination of the vertical impact forces (g) for the three trucks showed that g forces for each of the two bumps developed different magnitudes. Although the constructed size of the two bumps was the same, the physical conditions surrounding the bumps, such as approach aprons and road grade, caused measurable variations in the g forces transmitted to the cargo beds. As a result, the values for each of the trucks were divided into Bump 1 and Bump 2 groups. Tables IX, X, and XI show the g forces (average of 5 or 10 test runs per g value) from Bump 1 for the various loads, tire pressures, and speeds used for three truck types.

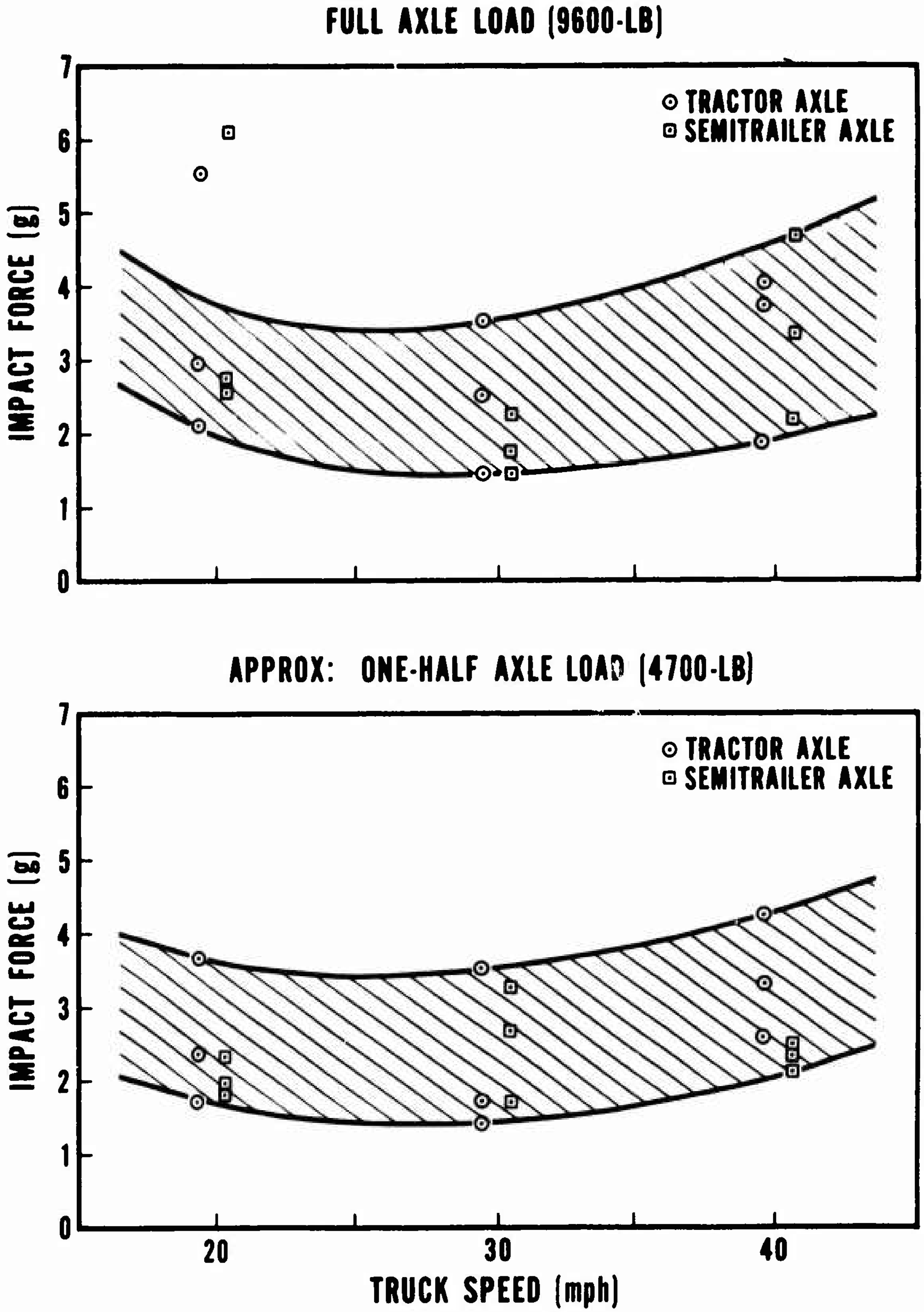


Figure 25. Impact Forces Versus Truck Speed on Truck Type II at Full- and One-Half Axle Loads.

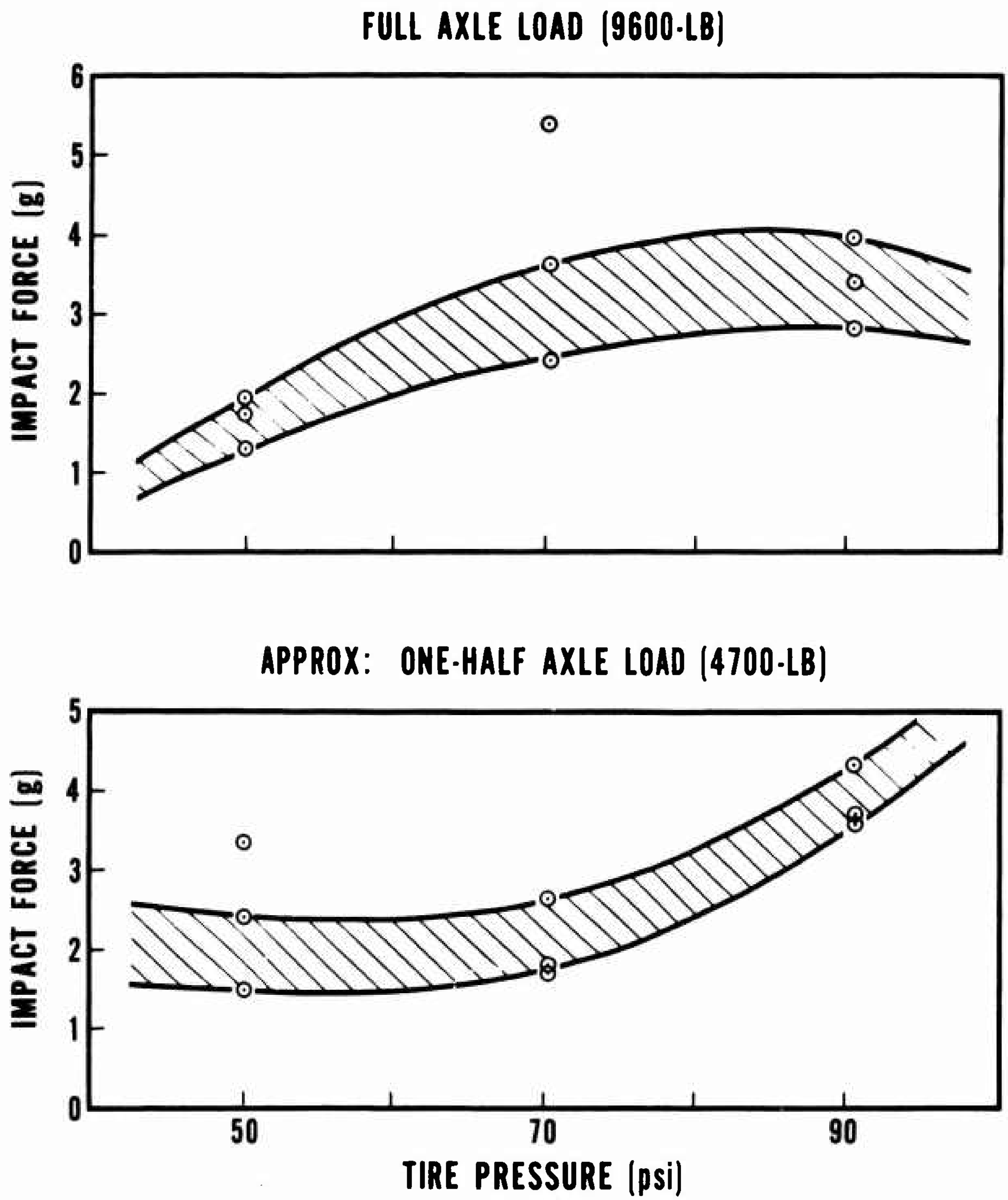


Figure 26. Impact Forces Versus Tire Pressure on Tractor Axle of Truck Type II at Full- and One-Half Axle Loads.

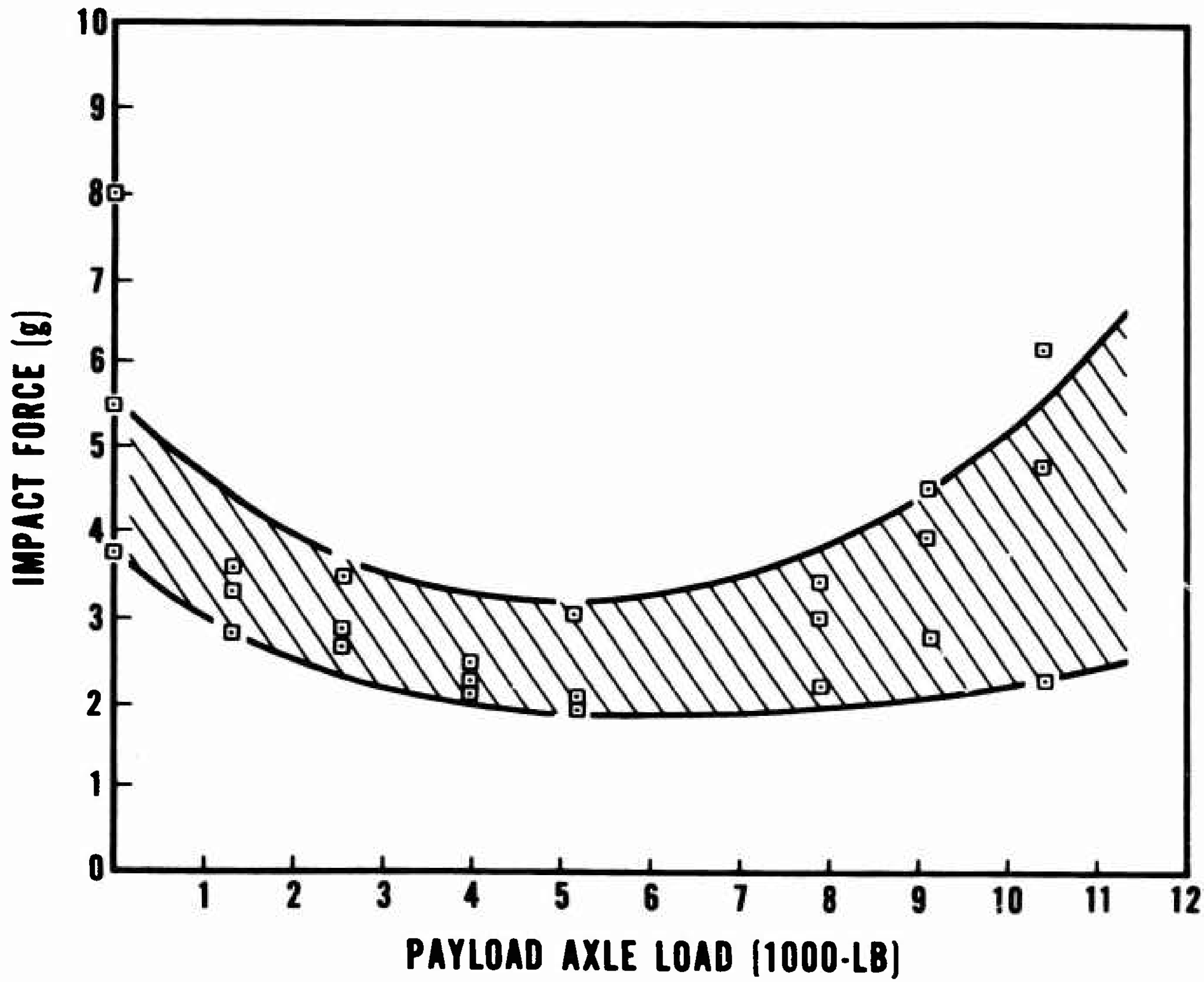


Figure 27. Impact Forces Versus Axle Load on Trailer Axle of Truck Type II at 70 psi Tire Pressure.

TABLE IX
VERTICAL IMPACT FORCES (g)
SUSTAINED BY TRUCK TYPE I AT VARIOUS SPEEDS OVER BUMP 1

Load Increment	Impact Force (g)								
	Front of Truck Bed			Center of Truck Bed			Rear of Truck Bed		
	Vehicle Speed (mph)								
	20	30	40	20	30	40	20	30	40
	Tire Pressure (50 psi)								
0	1.62	1.48	1.56	2.53	1.88	1.48	2.98	2.48	1.70
1/5	1.26	1.10	1.13	1.84	1.72	1.42	1.76	1.58	1.47
2/5	0.80	1.06	0.93	0.88	1.06	1.26	1.54	1.42	1.40
3/5	0.52	1.04	0.80	0.48	0.68	1.34	0.92	0.88	0.80
4/5	0.78	0.96	0.82	0.40	0.42	0.40	0.84	1.14	1.06
5/5	0.49	0.60	0.36	0.38	0.40	0.58	0.80	0.88	0.82
	Tire Pressure (70 psi)								
0	2.24	2.44	2.08	3.56	2.96	2.68	4.15	4.84	3.00
1/5	1.68	1.71	1.53	1.80	1.80	2.02	1.76	1.80	1.72
2/5	0.92	1.46	0.90	1.13	1.48	1.84	1.42	1.58	1.48
3/5	0.74	1.22	1.05	0.82	1.18	1.20	1.30	1.02	1.08
4/5	0.62	0.94	0.54	0.50	0.50	0.38	0.82	1.02	1.04
5/5	0.84	0.88	0.70	0.40	0.93	0.60	0.90	1.36	1.72
	Tire Pressure (90 psi)								
0	2.84	2.16	2.08	3.32	3.00	2.68	4.72	5.05	4.20
1/5	1.92	1.94	1.44	1.96	1.92	2.06	2.24	1.74	1.51
2/5	1.56	2.04	1.32	1.46	1.50	1.52	1.90	1.90	1.80
3/5	1.26	1.84	1.14	1.24	1.46	1.26	1.22	1.18	1.02
4/5	0.94	1.38	1.08	0.78	0.96	0.73	1.32	1.34	1.22
5/5	0.76	1.12	0.80	0.71	0.94	0.74	1.08	1.28	1.18

TABLE X
VERTICAL IMPACT FORCES (g)
SUSTAINED BY TRUCK TYPE II AT VARIOUS SPEEDS OVER BUMP 1

Load Increment	Impact Force (g)								
	Front of Trailer			Center of Trailer			Rear of Trailer		
	Vehicle Speed (mph)								
	20	30	40	20	30	40	20	30	40
	Tire Pressure (50 psi)								
0	4.96	4.60	3.95	3.76	3.16	3.72	5.48	4.75	7.80
1/8	4.00	2.92	6.16	2.68	2.20	3.52	2.68	3.05	3.25
1/4	1.72	1.80	3.12	3.35	2.68	4.35	2.88	2.55	3.65
3/8	1.84	1.40	2.76	2.12	1.92	2.56	2.80	2.04	1.96
1/2	2.36	1.44	3.32	2.20	1.32	2.44	1.92	1.68	2.40
3/4	3.08	2.56	2.80	1.56	1.96	2.68	1.60	1.36	2.80
7/8	2.28	1.25	1.56	1.56	0.92	2.04	2.64	1.70	3.24
8/8	2.12	1.48	1.92	0.44	0.40	1.44	2.60	1.48	3.40
	Tire Pressure (70 psi)								
0	4.52	7.10	8.16	2.44	3.16	3.96	3.76	5.45	8.04
1/8	8.28	7.76	7.20	2.48	2.96	3.04	2.84	3.36	3.60
1/4	3.08	3.16	4.60	2.60	3.76	4.80	2.75	3.50	2.92
3/8	5.75	5.36	5.08	2.36	2.25	2.56	2.20	2.28	2.56
1/2	1.75	1.72	2.60	2.70	1.92	2.04	1.95	3.12	2.12
3/4	2.96	2.20	2.96	2.52	2.56	2.40	3.05	2.25	3.45
7/8	7.32	5.45	7.44	2.40	1.56	2.16	4.56	2.80	3.95
8/8	5.55	2.56	3.80	2.52	1.50	2.32	6.12	2.32	4.75
	Tire Pressure (90 psi)								
0	3.48	5.15	7.35	3.28	3.76	5.20	6.04	4.35	8.88
1/8	4.04	5.12	6.40	2.76	3.04	4.44	3.52	3.16	3.25
1/4	5.68	3.80	6.52	3.36	4.24	5.28	3.44	4.10	4.48
3/8	2.95	4.52	7.00	2.30	2.64	2.80	2.35	2.52	3.55
1/2	3.65	3.56	4.24	2.44	2.20	2.28	2.30	2.64	2.32
3/4	2.60	2.30	7.20	2.65	2.28	3.08	2.40	2.00	2.36
7/8	4.25	4.08	3.68	1.92	2.40	2.12	2.32	2.08	2.72
8/8	2.96	3.55	4.10	2.16	1.48	1.80	2.68	1.80	2.12

TABLE XI
VERTICAL IMPACT FORCES (g)
SUSTAINED BY TRUCK TYPE III AT VARIOUS SPEEDS OVER BUMP 1

Load Increment	Impact Force (g)								
	Front of Semitrailer			Center of Semitrailer			Rear of Semitrailer		
	Vehicle Speed (mph)								
	20	30	40	20	30	40	20	30	40
	Tire Pressure (70 psi)								
0	5.28	4.36	4.20	7.40	7.92	8.60	6.80	7.60	8.76
1/5	2.60	3.24	3.52	3.28	4.32	4.44	5.45	5.00	5.56
2/5	4.35	6.00	5.20	2.64	3.24	3.00	5.04	4.50	5.00
3/5	3.75	1.92	1.80	2.24	3.68	5.60	4.15	3.40	4.40
4/5	3.95	3.60	2.36	1.96	3.45	3.24	2.55	6.80	6.95
5/5	5.70	8.15	6.40	2.48	2.80	2.52	2.30	8.40	8.10

The g forces resulting from the runs made at 70 pounds per square inch tire pressure, in general, fell between forces obtained at 50 and 90 psi. The use of the 50 and 90 psi tire pressures was mainly for information purposes and did not conflict with the trends obtained at 70 psi. The largest g forces recorded from the three arbitrarily chosen truck speeds, 20, 30, and 40 mph, at each load increment, was used since this approach would produce conservative shock index values.

CONSOLIDATION OF STATIC AND DYNAMIC TEST RESULTS

Convenient variable loading of the three trucks with the large concrete blocks produced a wide variation in the calculated axle loads. Payload axle loads were used since the empty weights of the trucks were not involved in determining shock indices. Table XII lists the payload axle loads corresponding to the loading increments for each truck type.

The vertical impact forces, or shock values (g), were plotted against the calculated axle payloads for the load-carrying axles of the three trucks, as shown in Figures 28, 29, and 30. These plots show that the measured shock reaches minimum values through the middle range of the payload axle loads. Also, when the axles are lightly or heavily loaded, the shock increases twofold. From these plots, a vertical shock can be determined for any payload placed on these trucks by knowing the load transmitted to these load-carrying axles.

TABLE XII
PAYLOAD AXLE LOADS FOR
LOAD INCREMENTS USED ON TEST TRUCKS

Load Increment Fraction of Rated Load	Payload Axle Load* (1,000 lb)	
Truck Type I	Rear Axle	
1/5	2.4	
2/5	3.6	
3/5	6.5	
4/5	8.5	
5/5	10.1	
Truck Type II	Tractor Rear Axle	Semitrailer Rear Axle
1/8	1.2	1.3
2/8	2.3	2.5
3/8	3.5	3.9
4/8	4.7	5.1
6/8	7.4	7.8
7/8	8.4	9.0
8/8	9.6	10.3
Truck Type III	Tractor Rear Axle	Semitrailer Rear Axle
1/5	2.6	2.4
2/5	5.2	4.8
3/5	7.6	7.3
4/5	10.0	9.8
5/5	12.5	12.4

*Refers to single axle on tandem axle truck.

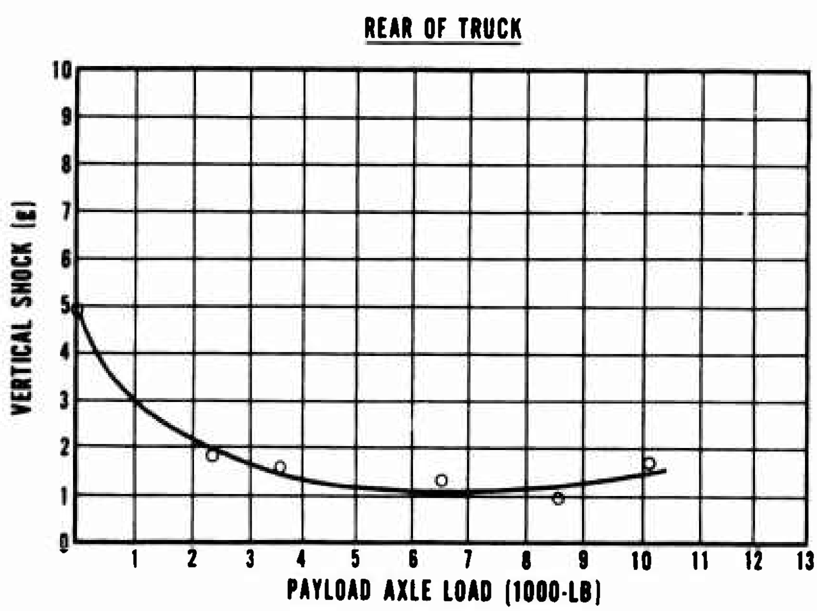


Figure 28. Truck Type I, Vertical Shock Versus Payload Axle Load.

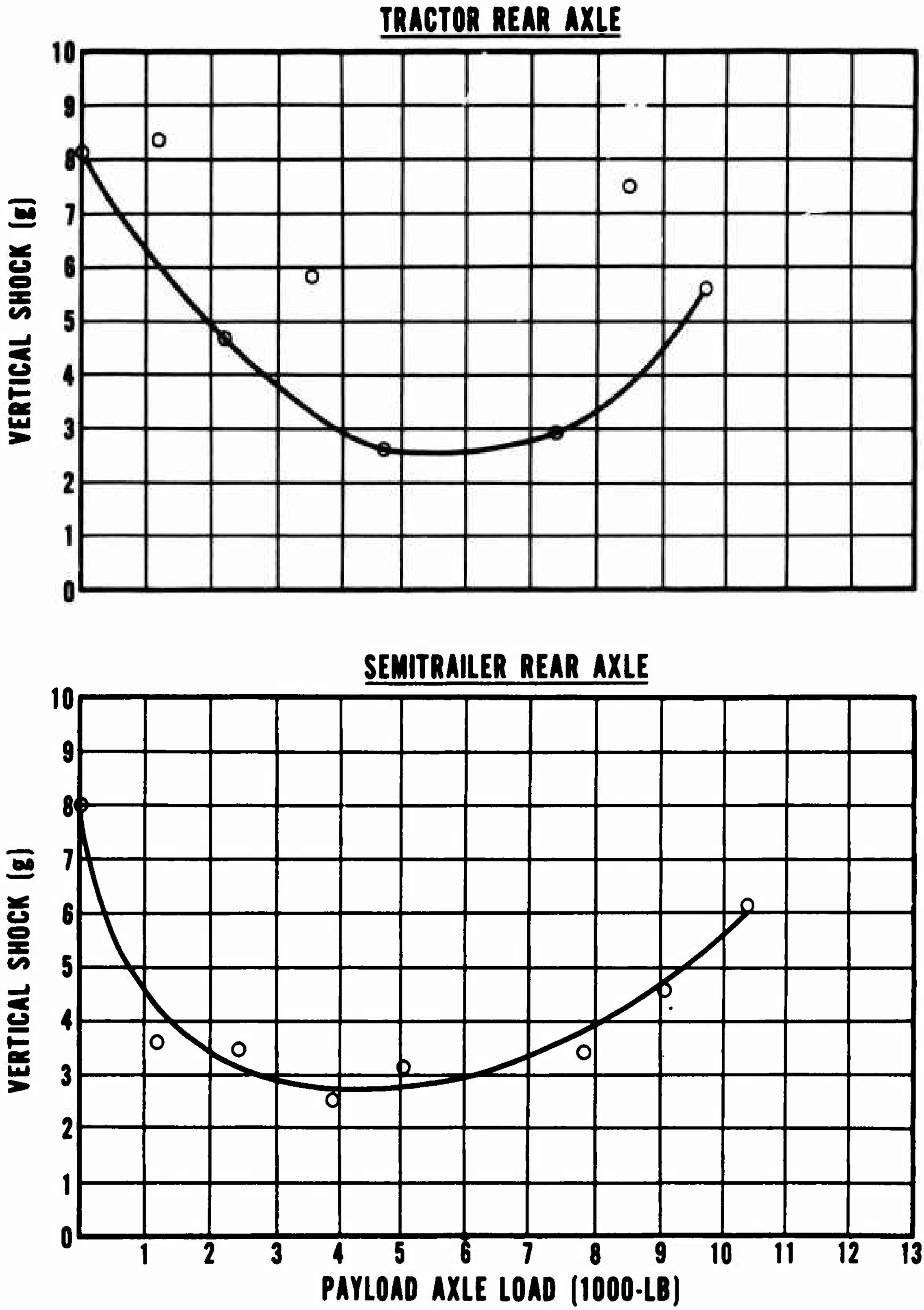


Figure 29. Truck Type II, Vertical Shock Versus Payload Axle Load.

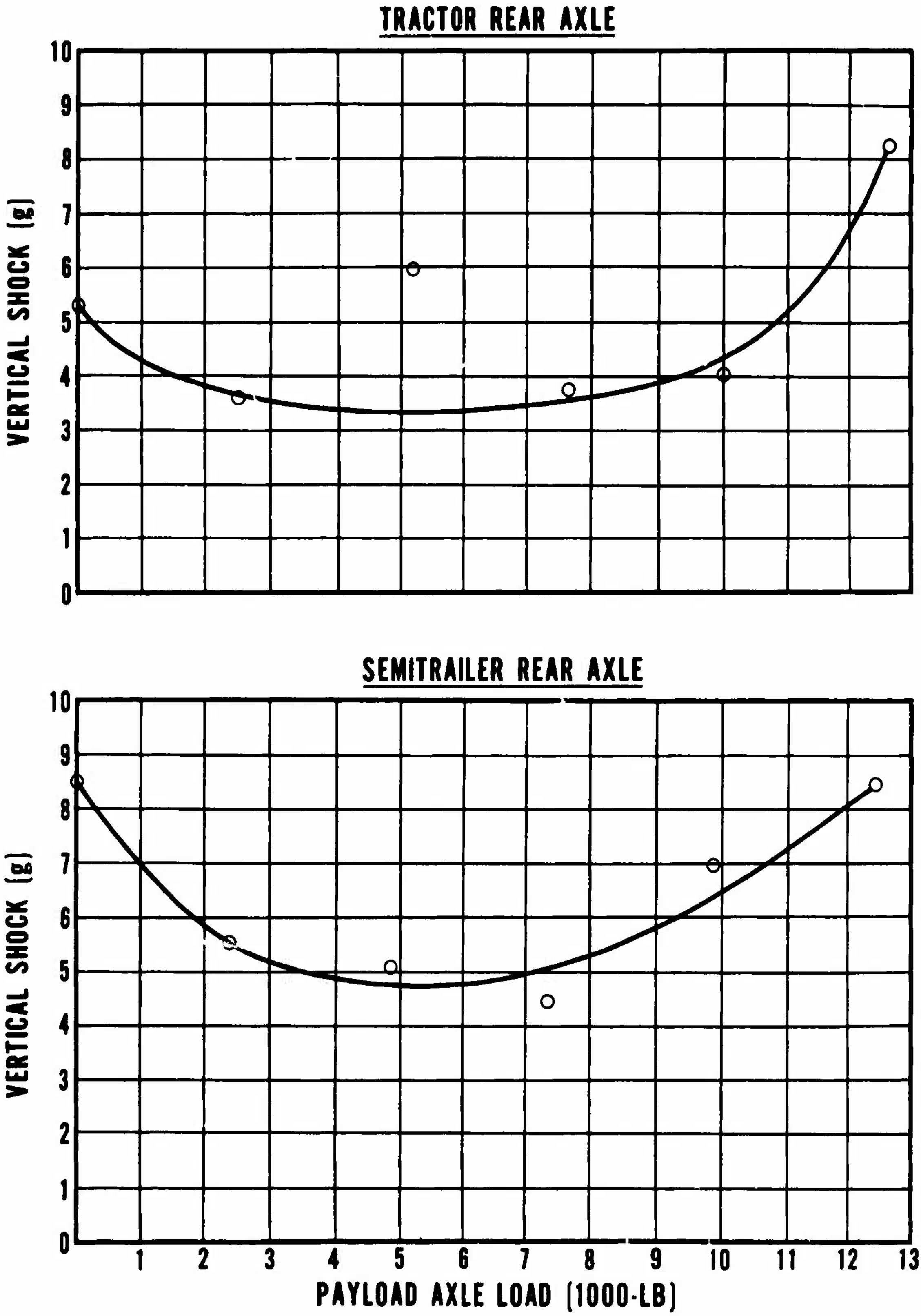


Figure 30. Truck Type III, Vertical Shock Versus Payload Axle Load.

Figure 29 shows the results for truck Type II, a tandem-axle tractor, tandem-axle trailer. The original loading increments were 1/4, 1/2, 3/4, and 4/4 of the rated load capacity. It was later decided to add 1/8, 3/8, and 7/8 load increments to supplement the original measured forces. Due to conditions beyond our control, such as weather, these additional test runs produced g forces of different magnitude than the original g forces, especially for the tractor rear axle.

As explained previously, a payload axle spring rate was calculated from the results of the static test. These axle spring rates are based upon payload variations; therefore, the term "payload axle spring rate in 1,000 pounds per inch (K)" vertical displacement is used. Table XIII shows the payload axle spring rates for the load-carrying axles of each truck.

TABLE XIII
PAYLOAD AXLE SPRING RATES

Truck Type	Load-Carrying Axle	Payload Axle Spring Rate (1,000 lb/in.)
I	Rear Axle	7,400
II	Tractor Rear Axle	12,600
	Semitrailer Rear Axle	8,600
III	Tractor Rear Axle	10,700
	Semitrailer Rear Axle	14,800

DEVELOPMENT OF SHOCK INDEX GRAPH

A procedure was devised for relating payload axle spring rate and payload axle load to the vertical shock that is expected from a vehicle with these two parameters. Accordingly, a shock index was developed that represented the range of vertical shocks measured in this test program. This shock index is based not on test truck configuration but on the payload axle spring rates of the trucks determined in the static test. Knowing the spring rate of an axle on a particular truck and the anticipated payload on that axle, a vertical impact force (g) or a shock index can be determined using the information given on Figure 31.

The graph is entered on the horizontal axis at the payload axle spring rate for the particular truck axle. Use 12,000 pounds per inch as an example. Proceed straight up to the line corresponding to the payload axle load expected on that axle, say, 9,000 pounds, then straight across to the vertical axis to read either the vertical g force, 5g; or the shock index, 2.5.

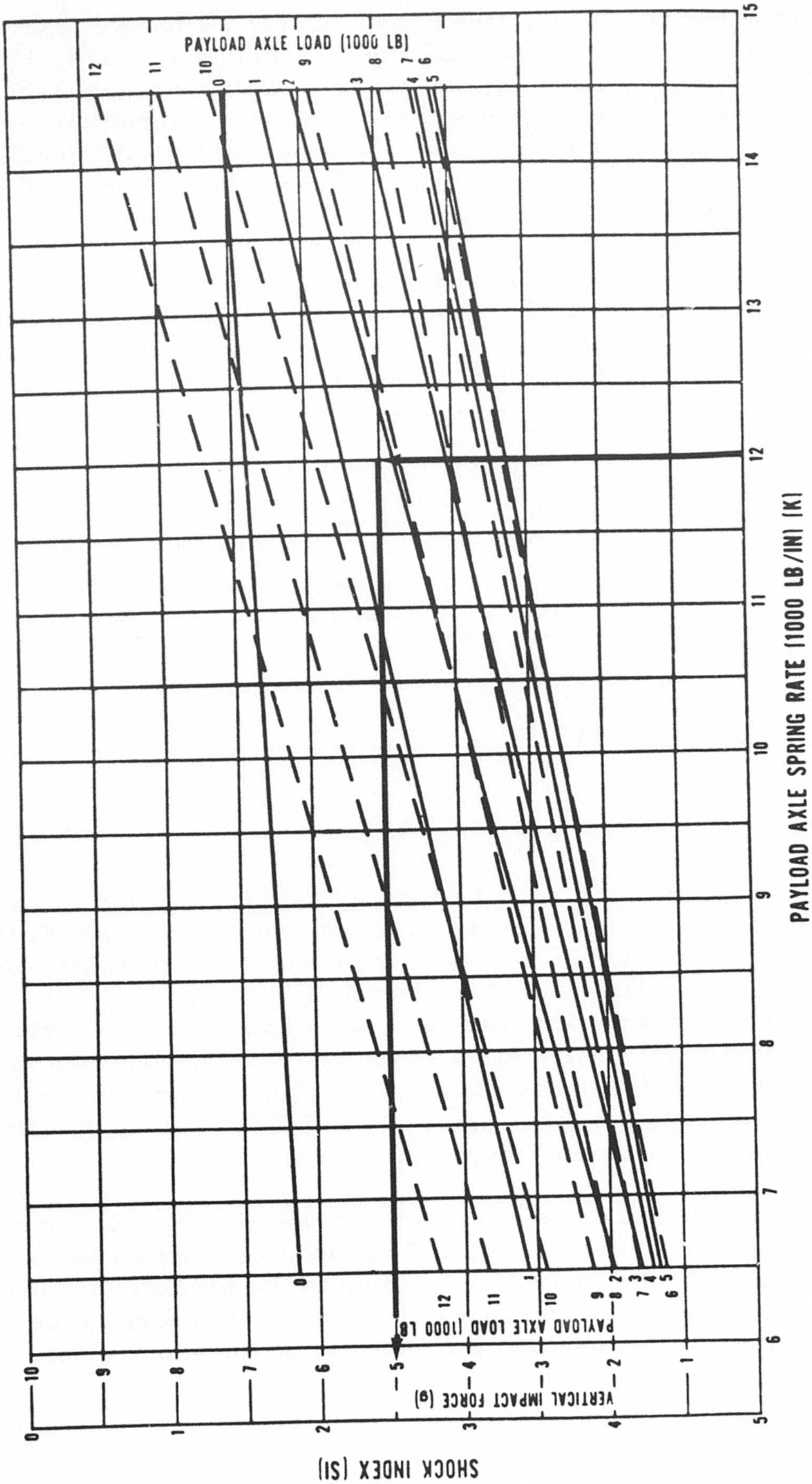


Figure 31. Shock Index Graph.

Results of the tests on these trucks indicated that at relatively low spring rates (6,000 to 3,000 lb/in.), impact forces transmitted to the cargo were low (1 to 4g); however, the impact forces increased significantly (4 to 8g) at the higher spring rates (12,000 to 15,000 lb/in). Results also showed that at a given spring rate as the payload is increased from 0, the impact forces decreased, providing a softer ride, to some minimum value. However, increasing the payload even further caused the impact forces to increase, providing a progressively rougher ride. This trend reversal is illustrated on Figure 31 by the dashed lines denoting payload axle loads from 6,000 pounds to 12,000 pounds. There was an optimum payload for all vehicles tested that provided the softest ride for the cargo. This optimum load can readily be selected from the graph when the payload axle spring rate for the vehicle is known.

SHOCK INDEX GRAPH

For all ranges of payload, due to the many variables, dynamic behavior, and variable environment associated with the vehicle-road relationship, some radical, inexplicable shock values will occur. In the test leading to the development of thr graph, approximately 20 percent of the recorded values fall within this category and were accordingly discarded.

When shock to the cargo is of concern the following conclusions can be drawn, based on the graph (see Figure 31).

High, erratic shock values are most likely to occur with either light or maximum payloads because at light loads the vehicle springs are relatively stiff, and at very heavy loads "bottoming out" of the springs may occur. The most erratic results will occur over the fifth wheel area due to the concentration of load at the kingpin.

The graph indicates that for a relatively soft ride the vehicle payload axle spring rate should be about 7,000 pounds per inch. For this condition for an axle payload of 3,000 pounds, the cargo would most likely not be subjected to a shock of over 2g, and the shock index rating for the vehicle would be about 4.1.

For a vehicle payload axle spring rate of 10,000 pounds per inch the maximum expected shock to the cargo should not exceed about 4g for axle payloads of 3,000 to 9,000 pounds. This vehicle would have a shock index of about 3.

For a vehicle payload axle spring rate of 13,000 pounds per inch the maximum expected shock to the cargo should not exceed about 6g for axle payloads of 3,000 to 9,000 pounds. This vehicle would have a shock index of about 2.4.

The foregoing examples illustrate that the SI provides classification for vehicle-load combinations and gives a better measure for shock than any single parameter.

VII. PROCEDURE FOR DETERMINING SHOCK INDEX

The procedure for estimating SI for a specific cargo truck involves two steps. First, it involves loading and unloading the truck and taking measurements on how much the cargo bed deflects under one-half and full payload. Second, it is necessary to know the payload axle load. This can be determined on a set of portable scales or by calculation. It is necessary that this information be obtained by physical measurements because of the high variable internal friction in leaf springs, variable stiffness in tire sidewalls, and general construction of the overall suspension system of the vehicle. Also, correlation between the manufacturer's spring rate for a leaf spring of a vehicle cannot be made with the installed spring, because in the manufacturer's test procedure, the test is performed without center clamps and shackles, and the spring ends are mounted on rollers so that they are free to move.[2] When the SI for a specific make and model of truck has been determined, it should apply to others of the same make and model, with the same types of springs and tires.

1. Required information.

a. Vertical deflection at one-half and full payload of truck bed at rear axle(s) and/or at rear axles of truck-tractor if the vehicle is a truck-tractor semitrailer combination.

b. Payload axle load causing the vertical deflections.

2. Determination of combined (springs and tires) vertical deflection at an axle(s).

a. Check tire air pressure, adjust to operating pressure.

b. Position axle(s) on scales; or, if scales are not available, on a uniformly smooth, level, unyielding surface with vehicle unloaded.

c. Accurately measure the height of the cargo bed on each side of the truck at the axle(s). If vehicle is on scales, note unloaded axle(s) load.

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[2] Society of Automotive Engineers (SAE) Handbook, "Leaf Springs for Motor Vehicle Suspension," Standards Information Reports Recommended Practices, J510a, p. 600, 1967.

d. Use dummy concentrated weights, if available, to simulate axle(s) payload. Load with center of gravity directly over axle of single-axle vehicles or midway between tandem axles. If concentrated weights are not available, use available homogeneous weights and uniformly load truck bed. Accurately measure the height of the cargo bed on each side of the truck at the axle(s) (Figure 32). The truck should be loaded and unloaded several times and an average deflection determined, both at one-half and full payload.

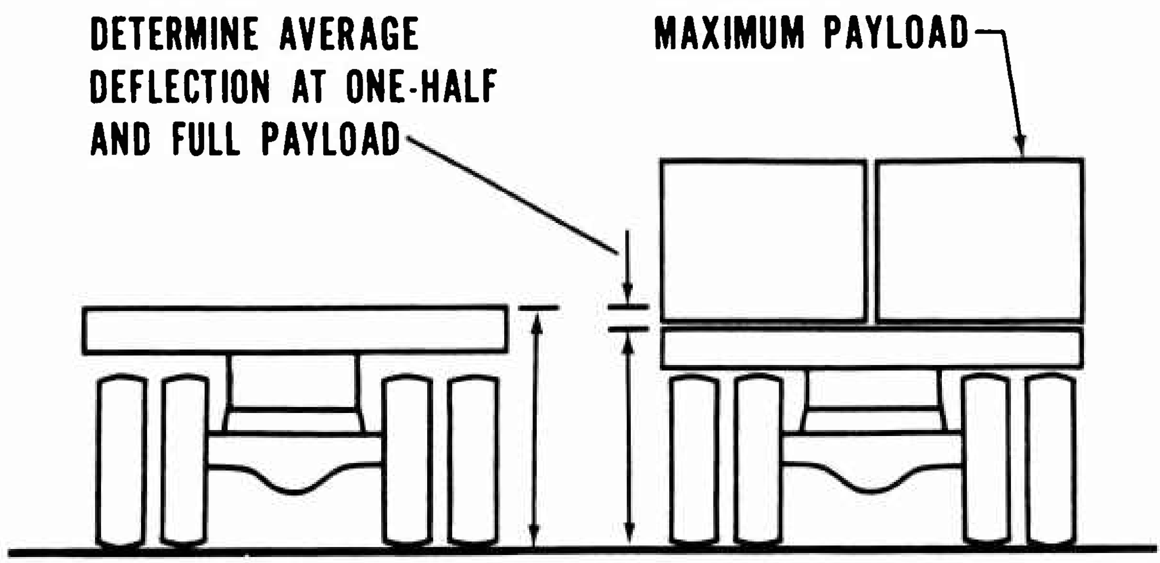


Figure 32. Rear View of Truck.

e. Proceed as follows in order to obtain accurate average deflections:

(1) Fully load the truck; measure truck bed height at full load.

(2) Unload to one-half of full load; measure truck bed height.

(3) Unload truck; measure truck bed height.

(4) Place one-half of full load on truck; measure truck bed height.

(5) Place full load on truck; measure truck bed height.

(6) Repeat above cycle 5 times for a total of 10 measurements.

(7) Make accuracy of measurements within one thirty-second of an inch.

3. Determination of payload per axle at one-half and full payload.

a. If vehicle is on scales, read recorded weight, subtract axle(s) unloaded weight; and, if tandem axles, divide by 2.

b. If scales are not available, use one of the following equations to determine the single axle payload at one-half and full payload (Figure 33).

4. Determination of combined payload spring rate (K) for axle(s).

$$K = \frac{\text{Full payload axle load (lb)} - \text{One-half payload axle load (lb)}}{\text{Average deflection at full payload (in.)} - \text{Average deflection at one-half payload (in.)}}$$

5. Determination of shock index.

Now that K has been determined for the axle(s), the SI can be read directly from the graph (see Figure 31) or Table XIV. The most accurate reading can be obtained by using the graph since a table must be made up based on some arbitrary interval of K. An interval of 500 pounds per inch is used for Table XIV.

To use the graph, enter the graph with K on horizontal scale, go vertically to axle payload for trip, and horizontally to read shock index. The shock index for each axle should be checked and the lower of the numerical values should be used for shock index; this will represent the roughest expected ride on the cargo bed. The shock index can be obtained, at the same time, for all axle payloads from 0 to 12,000 pounds. It need be determined only once for vehicles of the same make and model, with the same type springs and tires.

To use Table XIV, use the K in the table that most nearly corresponds numerically to the K determined by physical measurement. The maximum error in SI due to using the table will be 0.625; in most cases, the error will be considerably less. The SI for each axle (if the vehicle is a truck-tractor-semitrailer combination) should be checked, and the larger of the numerical values should be used for SI.

6. For example, determine the SI for a two-axle truck-tractor single-axle semitrailer combination. Payload axle loads for the rear axle of the tractor and trailer are to be 10,000 pounds each.

TABLE XIV
SHOCK INDEX PAYLOAD AXLE SPRING RATE (1,000 lb/in.) (K)

Payload Axle Load (1,000 lb)	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	Payload Axle Load (1,000 lb)
0	1.85	1.85	1.80	1.80	1.75	1.75	1.70	1.70	1.65	1.65	1.60	1.60	1.55	1.55	1.50	1.50	1.45	0
1	3.40	3.30	3.20	3.10	3.00	2.90	2.75	2.65	2.55	2.45	2.35	2.25	2.15	2.05	1.95	1.80	1.70	1
2	4.00	3.85	3.75	3.60	3.50	3.35	3.20	3.10	2.95	2.85	2.70	2.60	2.45	2.35	2.25	2.10	1.95	2
3	4.20	4.05	3.95	3.85	3.75	3.60	3.50	3.40	3.30	3.15	3.05	2.95	2.85	2.70	2.60	2.50	2.40	3
4	4.25	4.15	4.05	3.95	3.90	3.80	3.70	3.50	3.50	3.40	3.35	3.25	3.15	3.05	2.95	2.85	2.75	4
5	4.30	4.20	4.10	4.05	3.95	3.85	3.75	3.70	3.60	3.55	3.45	3.35	3.25	3.15	3.10	3.00	2.90	5
6	4.35	4.25	4.15	4.05	3.95	3.85	3.75	3.70	3.60	3.50	3.40	3.30	3.25	3.15	3.05	2.95	2.85	6
7	4.15	4.05	3.95	3.90	3.80	3.70	3.65	3.55	3.45	3.35	3.30	3.20	3.10	3.00	2.90	2.85	2.75	7
8	4.00	3.90	3.80	3.70	3.60	3.55	3.45	3.35	3.25	3.15	3.05	2.95	2.90	2.80	2.70	2.10	2.00	8
9	3.90	3.75	3.65	3.55	3.40	3.30	3.20	3.10	2.95	2.85	2.75	2.60	2.50	2.40	2.30	2.15	1.95	9
10	3.55	3.40	3.25	3.10	3.00	2.85	2.75	2.60	2.45	2.30	2.20	2.05	1.90	1.80	1.65	1.50	1.40	10
11	3.15	3.00	2.90	2.75	2.60	2.50	2.35	2.25	2.10	2.05	1.85	1.70	1.55	1.45	1.30	1.15	1.05	11
12	2.80	2.65	2.55	2.40	2.25	2.10	2.00	1.85	1.70	1.60	1.45	1.30	1.20	1.05	0.90	0.75	0.65	12

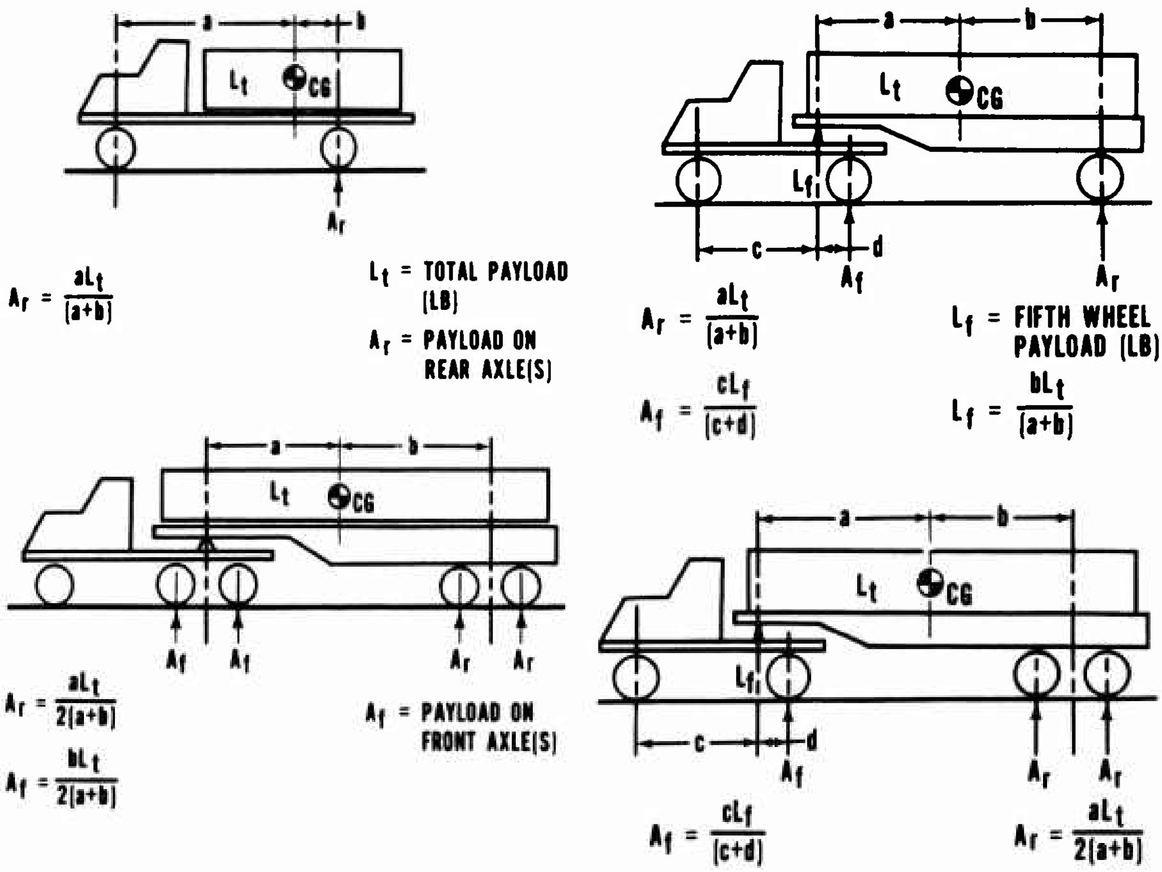


Figure 33. Equations for Determining Single Axle Payloads.

The truck was loaded to one-half and full payload and deflections were measured. Scales were used to determine the payload axle load on each axle. The following data were obtained on the trailer axle:

Full payload axle load - 12,288 lb

One-half payload axle load - 6,123 lb

Average deflection at full payload - 1.127 in.

Average deflection at one-half payload - 0.687 in.

$$K = \frac{12,288 - 6,123}{1.127 - 0.687} = 14,000 \text{ lb/in.}$$

Enter Table XIV with K; go vertically to payload axle load that truck is to transport (10,000 pounds); horizontally to read shock index, which is 1.50 for a K of 14,000 pounds and payload axle load of 10,000 pounds. SI from Table XIV is 1.50.

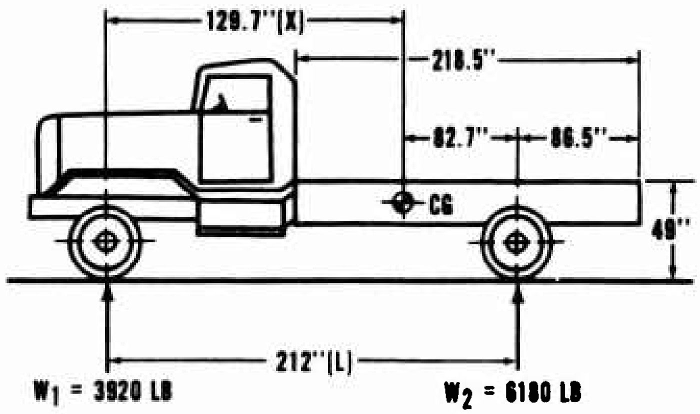
This procedure should be used also on the rear axle of the truck-tractor and the lower of the two SI used as the SI for that truck (with 10,000-pound payload axle loads). The SI for all other payload axle loads can be determined directly from the graph or table using the value of K for the truck, since K is independent of the payload.

APPENDIX A

DATA ON TRUCK TYPE I

Data developed during the static and dynamic tests on truck Type II were analyzed in detail and presented in the body of the report. Results from tests on truck Type I, which are similar to truck Type II, are presented in this appendix. Figures 34 through 42 show physical characteristics of the truck Type I. They also show loading configurations and payload axle spring rates for the rear axle and typical accelerometer trace of shocks recorded on the bed of the truck. Tables XV through XXI show the static vertical measurements at various tire pressures of truck Type I and the test conditions and the loading arrangements of static and dynamic tests.

VEHICLE CG EMPTY



(TOTAL WT) $W = W_1 + W_2$

$W = 3920 \text{ LB} + 6180 \text{ LB}$

$W = 10100 \text{ LB}$

$$CG(X) = \frac{(L)W_2}{W}$$

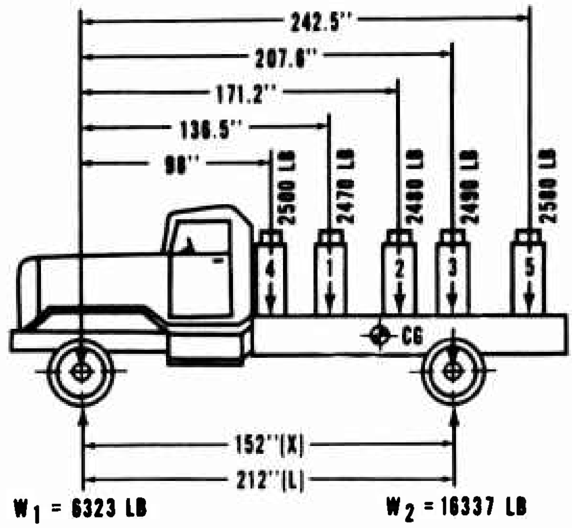
$$CG(X) = \frac{(212")(6180 \text{ LB})}{10100 \text{ LB}}$$

$$CG(X) = 129.72"$$

NOTES:
18-FT FLATBED-STAKE BODY
GVW = 23000 LB
LIMIT LOAD = 13000 LB

Figure 34. Dimensions and Weight, Truck Type I.

VEHICLE CG FULL LOAD



(TOTAL WT) $W = W_1 + W_2$

$W = 6323 \text{ LB} + 16337 \text{ LB}$

$W = 22660 \text{ LB}$

$$CG(X) = \frac{(L)W_2}{W}$$

$$CG(X) = \frac{(212)(16337)}{22660}$$

$$CG(X) = 152''$$

Figure 35. Static Test, Full Load, Center of Gravity, Truck Type I.

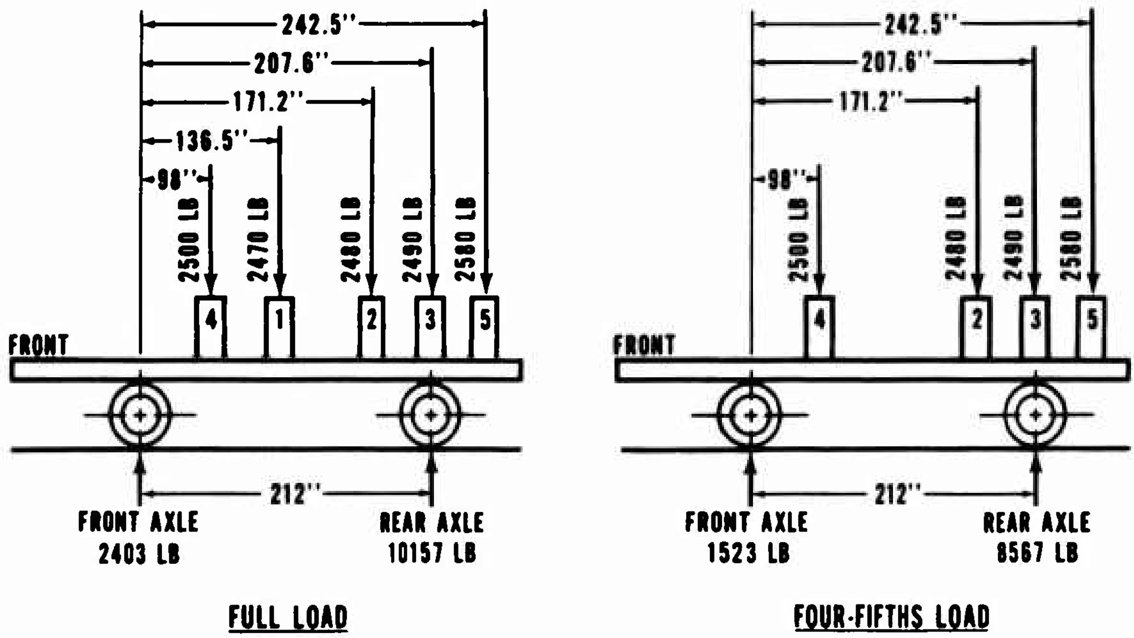


Figure 36. Static Test, Full- and Four-Fifths Load, Truck Type I.

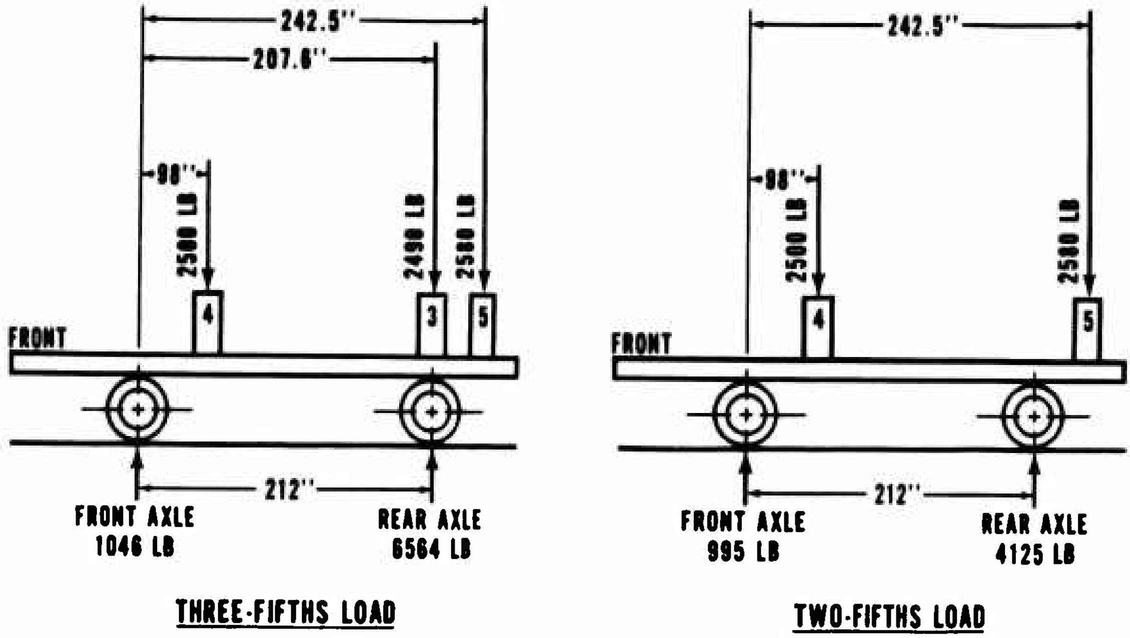


Figure 37. Static Test, Three-Fifths and Two-Fifths Load, Truck Type I.

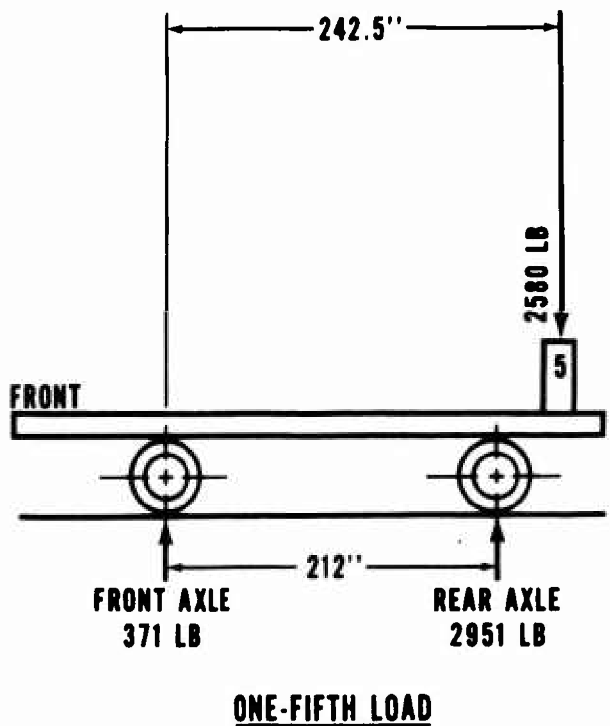


Figure 38. Static Test, One-Fifth Load, Truck Type I.

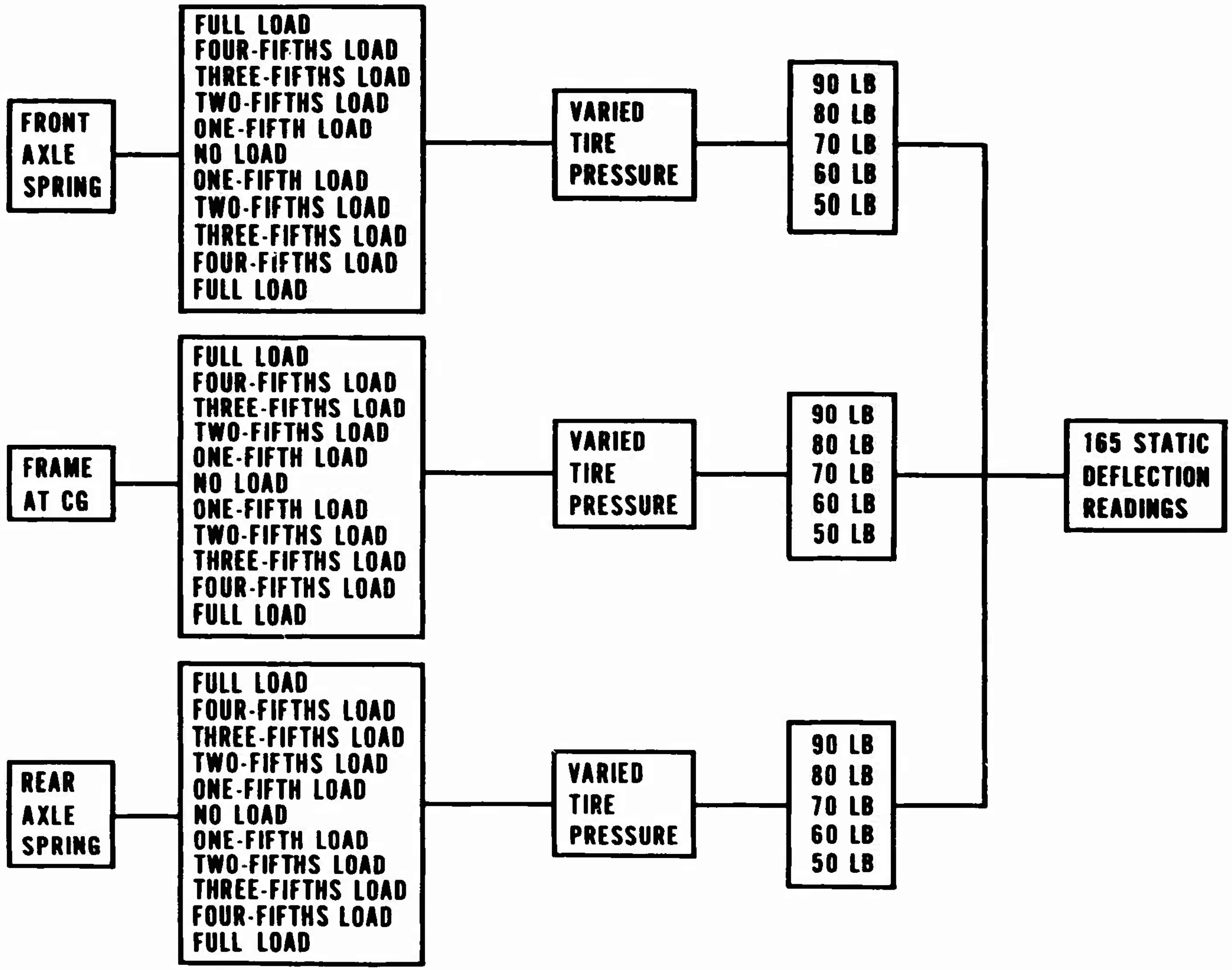


Figure 39. Static Loading Test Procedure, Truck Type I.

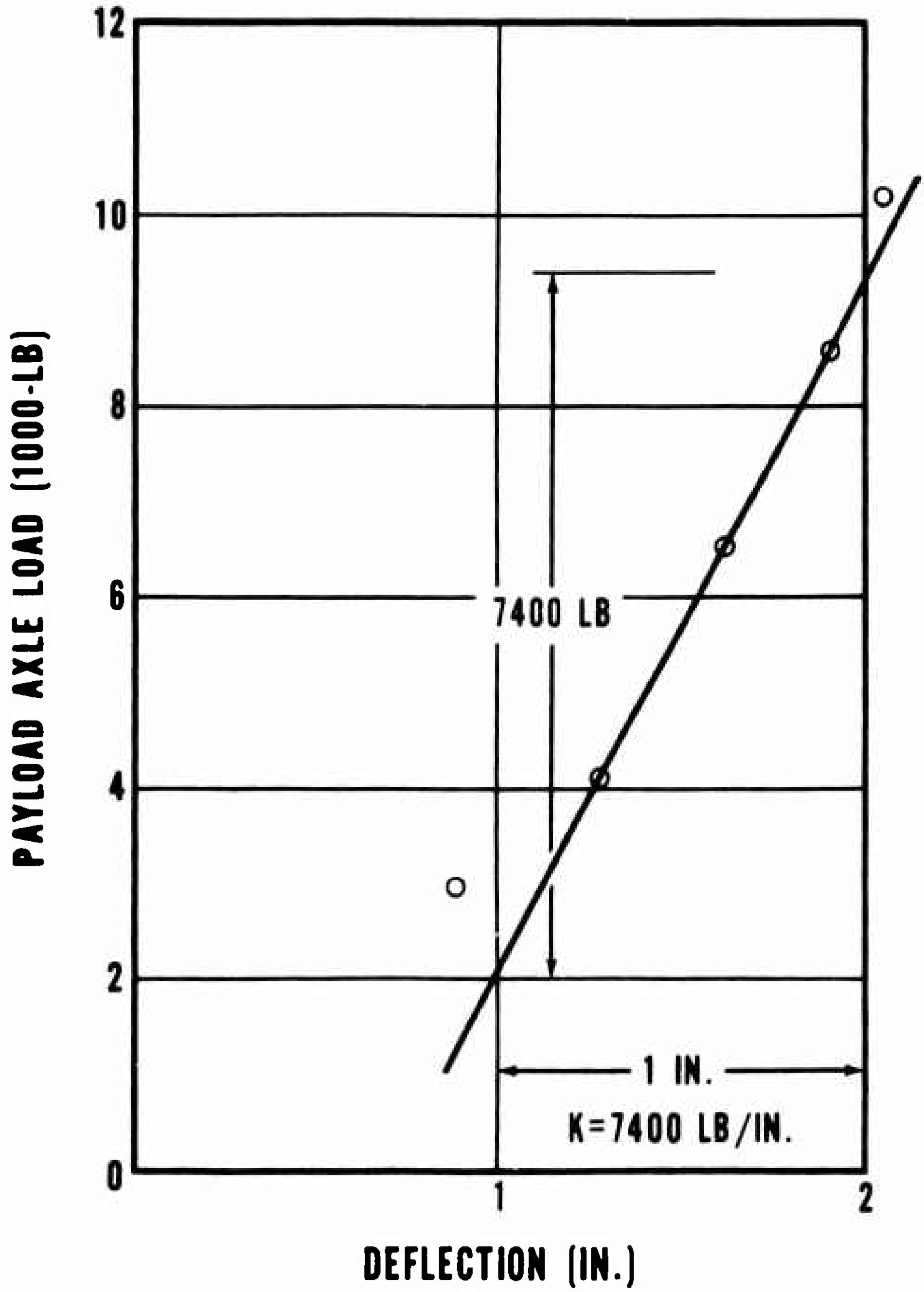
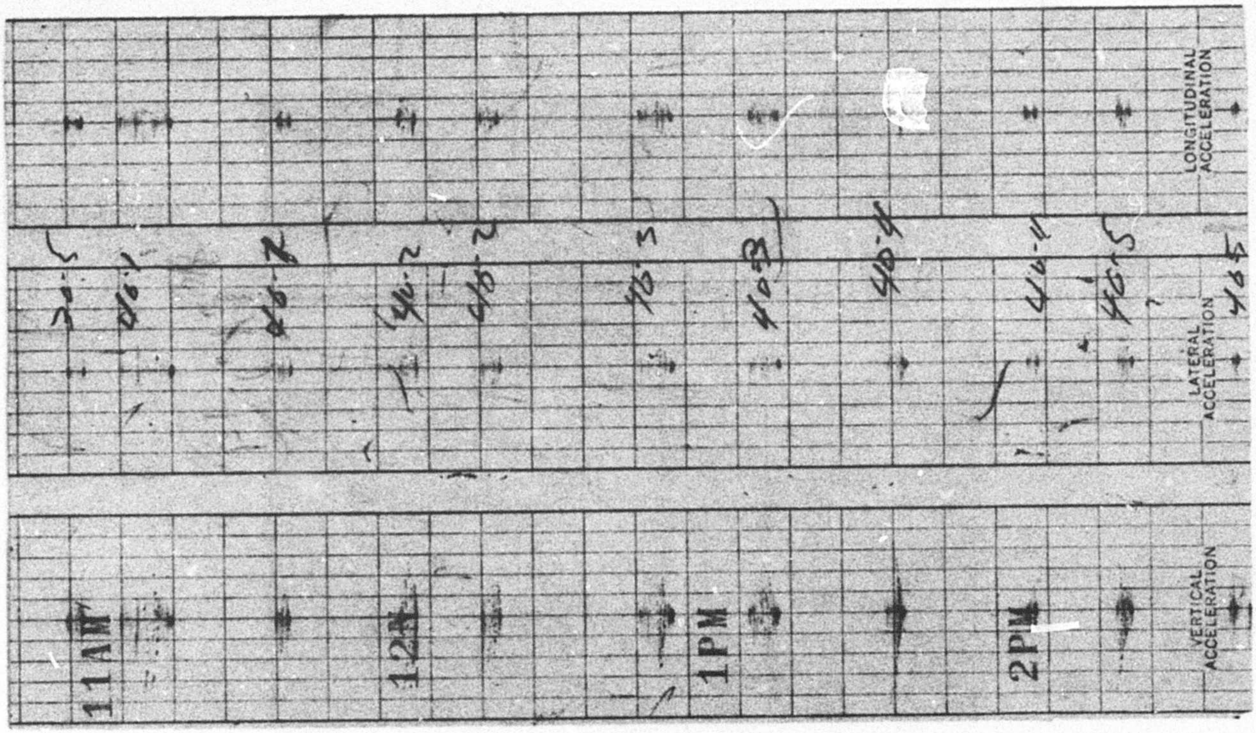
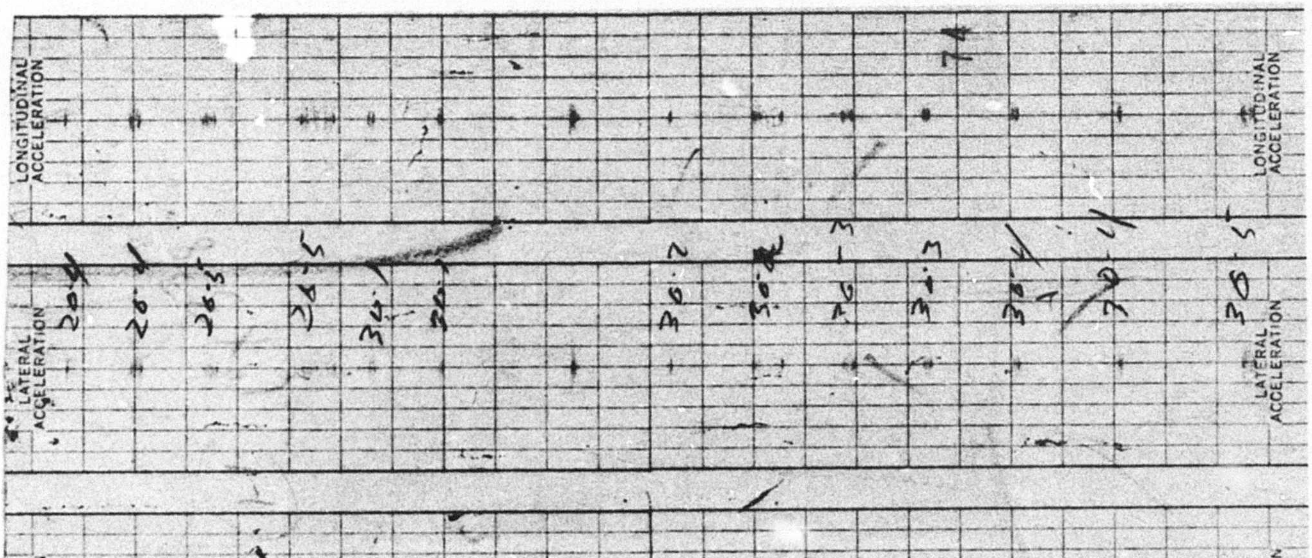


Figure 40. Payload Axle Spring Rate (K) for Rear Axle on Truck Type I.

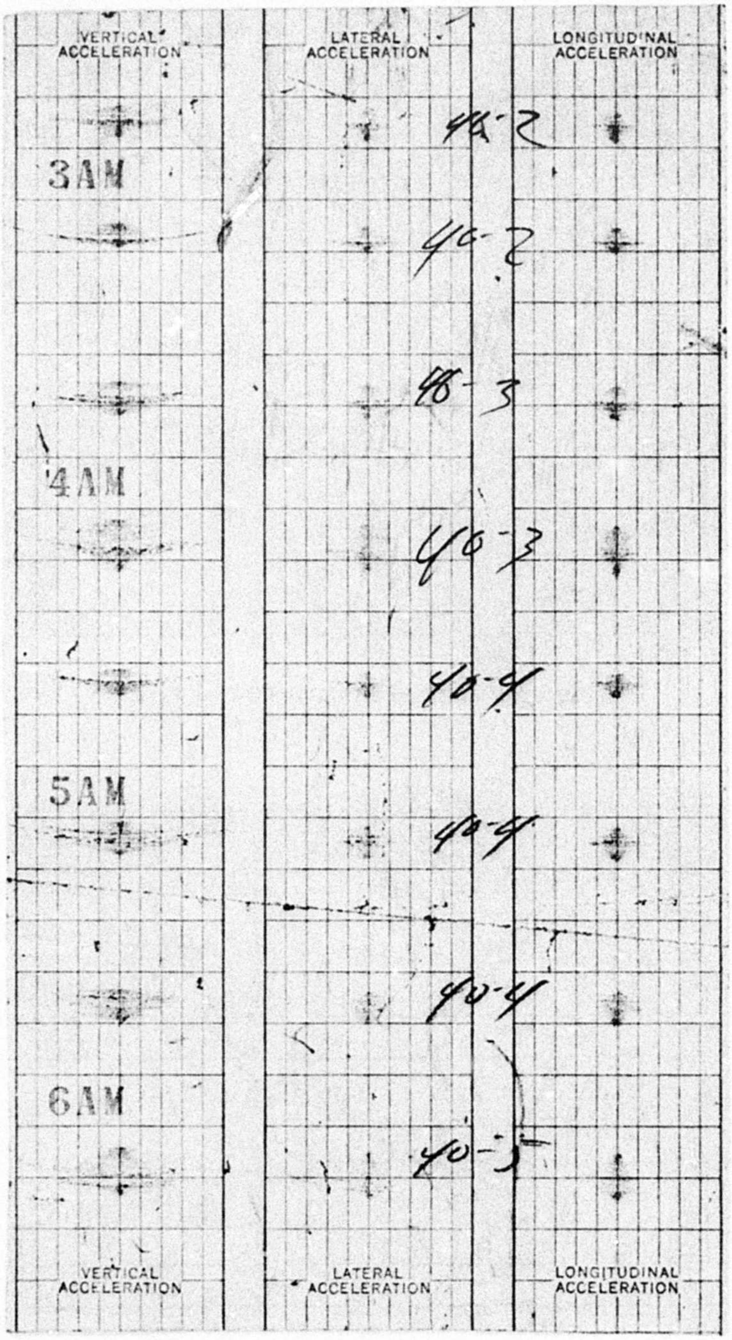


Forward Accelerometer Trace



Midaccelerometer Trace

Figure 41. Typical Accelerometer Readouts for Truck Type I.



Rear Accelerometer Trace

Figure 42. Typical Accelerometer Readout for Truck Type I.

TABLE XV

TRUCK TYPE I, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 50 PSI TIRE PRESSURE

		Static Measurement (in.)				Static Deflection (in.)					
Block No.	Load (lb)	Front Springs and Tires	Front Tires	Rear Springs and Tires	Rear Tires	Front Springs	Front Tires	Front Springs and Tires	Rear Springs	Rear Tires	Rear Springs and Tires
5, 6 11, 12, 10	Full (12,800)	19.000	12.438	28.656	11.844	0.782	0.343	1.125	1.563	0.656	2.219
6 12, 10, 5	4/5 (10,264)	19.344	12.625	28.781	12.188	0.625	0.156	0.781	1.782	0.312	2.094
12, 10, 6	3/5 (7,738)	19.844	12.781	28.938	12.031	0.281	0.000	0.468	1.468	0.469	1.937
12, 10	2/5 (5,182)	20.125	12.875	29.281	12.025	0.094	-0.094	0.000	1.119	0.475	1.594
10	1/5 (2,546)	20.156	12.875	29.875	12.344	0.063	-0.094	-0.031	0.844	0.156	1.000
0	0	20.125	12.781	30.875	12.500	0.000	0.000	0.000	0.000	0.000	0.000
10	1/5 (2,546)	20.125	12.844	30.375	12.375	0.063	-0.063	0.000	0.375	0.125	0.500
12, 10	2/5 (5,182)	20.250	12.906	29.688	12.281	0.000	-0.125	-0.125	0.968	0.219	1.187
12, 10, 6	3/5 (7,738)	20.156	12.813	29.281	12.031	0.001	-0.032	-0.031	1.125	0.469	1.594
6 12, 10, 5	4/5 (10,264)	19.844	12.688	29.031	11.938	0.188	0.093	0.281	1.282	0.562	1.844
5, 6 11, 12, 10	Full (12,800)	19.063	12.469	28.813	11.878	0.750	0.312	1.062	1.440	0.622	2.062

TABLE XVI

TRUCK TYPE I, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 60 PSI TIRE PRESSURE

Static Measurement (in.)						Static Deflection (in.)					
Block No.	Load (lb)	Front Springs and Tires	Front Tires	Rear Springs and Tires	Rear Tires	Front Springs	Front Tires	Front Springs and Tires	Rear Springs	Rear Tires	Rear Springs and Tires
5, 6 11, 12, 10	Full (12,800)	19.188	12.625	28.969	12.094	0.656	0.344	1.000	1.343	0.719	2.062
6 12, 10, 5	4/5 (10,264)	19.150	12.813	29.000	12.094	0.882	0.156	1.038	1.312	0.719	2.031
12, 10, 6	3/5 (7,738)	19.875	12.969	29.375	12.313	0.313	0.000	0.313	1.156	0.500	1.656
12, 10	2/5 (5,182)	20.219	13.031	29.500	12.375	0.031	-0.062	-0.031	1.093	0.438	1.531
10	1/5 (2,546)	20.281	13.031	29.969	12.563	-0.031	-0.062	-0.093	0.812	0.250	1.062
0	0	20.188	12.969	31.031	12.813	0.000	0.000	0.000	0.000	0.000	0.000
10	1/5 (2,546)	20.250	13.000	30.188	12.688	0.248	-0.310	-0.062	0.718	0.125	0.843
12, 10	2/5 (5,182)	20.313	13.031	29.875	12.406	-0.063	-0.062	-0.125	0.749	0.407	1.156
12, 10, 6	3/5 (7,738)	20.250	13.000	29.500	12.375	-0.031	-0.031	-0.062	1.093	0.438	1.531
6 12, 10, 5	4/5 (10,264)	19.969	12.875	29.188	12.250	0.125	0.094	0.219	1.280	0.563	1.843
5, 6 11, 12, 10	Full (12,800)	19.313	12.656	28.969	12.156	0.562	0.313	0.875	1.405	0.657	2.062

TABLE XVII

TRUCK TYPE I, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 70 PSI TIRE PRESSURE

		Static Measurement (in.)				Static Deflection (in.)					
Block No.	Load (lb)	Front Springs and Tires	Front Tires	Rear Springs and Tires	Rear Tires	Front Springs	Front Tires	Front Springs and Tires	Rear Springs	Rear Tires	Rear Springs and Tires
5, 6 11, 12, 10	Full (12, 800)	18.625	12.688	28.969	12.094	1.500	0.375	1.875	1.313	0.781	2.094
6 12, 10, 5	4/5 (10, 264)	19.188	12.875	29.031	12.250	1.124	0.188	1.312	1.407	0.625	2.032
12, 10, 6	3/5 (7, 738)	19.969	13.031	29.438	12.375	0.499	0.032	0.531	1.125	0.500	1.625
12, 10	2/5 (5, 182)	20.406	13.094	29.563	12.500	0.125	-0.031	0.094	1.125	0.375	1.500
10	1.5 (2, 546)	20.563	13.094	29.781	12.625	-0.032	-0.031	-0.063	1.032	0.250	1.282
0	0	20.500	13.063	31.063	12.875	0.000	0.000	0.000	0.000	0.000	0.000
10	1/5 (2, 546)	20.500	13.063	30.625	12.688	0.000	0.000	0.000	0.251	0.187	0.438
12, 10	2/5 (5, 182)	20.563	13.094	30.031	12.531	-0.032	-0.031	-0.063	0.688	0.344	1.032
12, 10, 6	3/5 (7, 738)	20.500	13.063	29.563	12.469	0.000	0.000	0.000	1.094	0.406	1.500
6 12, 10, 5	4/5 (10, 264)	20.156	12.938	29.281	12.438	0.219	0.125	0.344	1.345	0.437	1.782
5, 6 11, 12, 10	Full (12, 800)	19.375	12.750	29.094	12.250	0.812	0.313	1.125	1.344	0.625	1.969

TABLE XVIII

TRUCK TYPE I, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 80 PSI TIRE PRESSURE

		Static Measurement (in.)				Static Deflection (in.)					
Block No.	Load (lb)	Front Springs and Tires	Front Tires	Rear Springs and Tires	Rear Tires	Front Springs	Front Tires	Front Springs and Tires	Rear Springs	Rear Tires	Rear Springs and Tires
5, 6 11, 12, 10	Full (12, 800)	19.344	12.813	29.281	12.313	0.813	0.281	1.094	1.251	0.656	1.907
6 12, 10, 5	4/5 (10, 264)	19.625	13.000	29.375	12.344	0.719	0.094	0.813	1.188	0.625	1.813
12, 10, 6	3/5 (7, 738)	20.031	13.156	29.500	12.500	0.4[illegible]9	-0.062	0.407	1.219	0.469	1.688
12, 10	2/5 (5, 182)	20.375	13.188	29.781	12.656	0.1[illegible]7	-0.094	0.063	1.094	0.313	1.407
10	1/5 (2, 546)	20.406	13.125	30.250	12.750	0.063	-0.031	0.032	0.719	0.219	0.938
0	0	20.438	13.094	31.188	12.969	0.000	0.000	0.000	0.000	0.000	0.000
10	1/5 (2, 546)	20.719	13.281	30.688	12.781	-0.094	-0.187	-0.281	0.312	0.188	0.500
12, 10	2/5 (5, 182)	20.813	13.219	30.188	12.719	-0.250	-0.125	-0.375	0.750	0.250	1.000
12, 10, 6	3/5 (7, 738)	20.688	13.156	29.813	12.531	-0.188	-0.062	-0.250	0.937	0.438	1.375
6 12, 10, 5	4/5 (10, 264)	20.313	13.031	29.500	12.469	0.062	+0.063	0.125	1.188	0.500	1.688
5, 6 11, 12, 10	Full (12, 800)	19.531	12.844	29.250	12.313	0.657	+0.250	0.907	1.282	0.656	1.938

TABLE XIX

TRUCK TYPE I, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 90 PSI TIRE PRESSURE

		Static Measurement (in.)				Static Deflection (in.)					
Block No.	Load (lb)	Front Springs and Tires	Front Tires	Rear Springs and Tires	Rear Tires	Front Springs	Front Tires	Front Springs and Tires	Rear Springs	Rear Tires	Rear Springs and Tires
5, 6 11, 12, 10	Full (12, 800)	18.875	12.938	29.094	12.469	1.313	0.250	1.563	1.593	0.594	2.187
6 12, 10, 5	4/5 (10, 264)	19.313	13.063	29.250	12.500	1.000	0.125	1.125	1.468	0.563	2.031
12, 10, 6	3/5 (7, 738)	19.969	13.188	29.406	12.625	0.469	0.000	0.469	1.437	0.438	1.875
12, 10	2/5 (5, 182)	20.438	13.250	29.750	12.750	-0.062	0.062	0.000	1.218	0.313	1.531
10	1/5 (2, 546)	20.[illegible]75	13.188	30.281	12.844	0.063	0.000	0.063	0.781	0.219	1.000
0	0	20.438	13.188	31.281	13.063	0.000	0.000	0.000	0.000	0.000	0.000
10	1/5 (2, 546)	20.531	13.188	30.875	12.875	-0.093	0.000	-0.093	0.218	0.188	0.406
12, 10	2/5 (5, 182)	20.625	13.250	30.281	12.750	-0.125	-0.062	-0.187	0.687	0.313	1.000
12, 10, 6	3/5 (7, 738)	20.563	13.313	29.875	12.625	0.000	-0.125	-0.125	0.968	0.438	1.406
6 12, 10, 5	4/5 (10, 264)	20.250	13.063	29.625	12.531	0.063	0.125	0.188	1.124	0.532	1.656
5, 6 11, 12, 10	Full (12, 800)	19.500	12.875	29.344	12.500	0.625	0.313	0.938	1.374	0.563	1.937

TABLE XX
TRUCK TYPE I, DYNAMIC LOADING AND OPERATIONAL TEST PROCEDURE

Tire Pressure (70 lb)								
Impact Register Location	Speed (mph)	Load Increment						
At Bulkhead	20, 30, 40	Full	4/5	3/5	2/5	1/5	0	
At Center of Gravity	20, 30, 40	Full	4/5	3/5	2/5	1/5	0	
Over Rear Axle	20, 30, 40	Full	4/5	3/5	2/5	1/5	0	

NOTES:
The variaole load and dynamic test conditions were imposed on the vehicle for 10 complete circuits of the road course.

Variables:

Three - Tire Pressure (90, 70, and 50 lb)
Six - Load Increments (Full, 4/5, 3/5, 2/5, 1/5, 0)
Three - Speeds (20, 30, and 40 mph)

There were 3, 240 readings for three recorders.

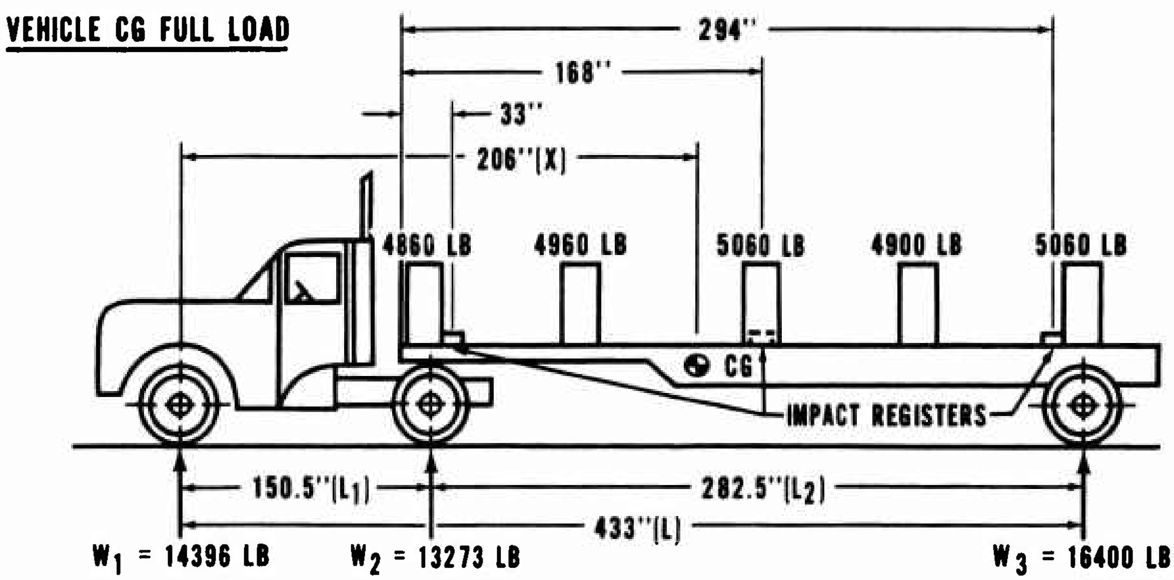
TABLE XXI
LOADING ARRANGEMENT, STATIC AND DYNAMIC TESTS, TRUCK TYPE I

Full Load		4/5 Load		3/5 Load		2/5 Load		1/5 Load	
Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)
1	2,470								
2	2,480	2	2,480						
3	2,490	3	2,490	3	2,490				
4	2,500	4	2,500	4	2,500	4	2,500		
5	2,580	5	2,580	5	2,580	5	2,580	5	2,580
Total	12,520	Total	10,050	Total	7,570	Total	5,080	Total	2,580
Payload Axle Load (lb)									
Front Axle	Rear Axle	Front Axle	Rear Axle	Front Axle	Rear Axle	Front Axle	Rear Axle	Front Axle	Rear Axle
2,403	10,157	1,523	8,567	1,046	6,564	995	4,125	371	2,951

APPENDIX B

DATA ON TRUCK TYPE III

Data developed during the static and dynamic tests on truck Type II were analyzed in detail and presented in the body of the report. Results from tests on truck Type III, which are similar, are presented in this appendix. Figures 43 through 52 show physical characteristics of the truck Type III. They also show loading configurations and payload axle spring rate for the rear axle of the tractor and trailer and typical accelerometer trace of shocks recorded on the bed of the truck. Tables XXII through XXVI show the static vertical measurements at various tire pressures of truck Type III and the test conditions and the loading arrangements of static and dynamic tests.



$$CG(X) = \frac{(L_1)W_2 + (L)W_3}{W_{1,2,3}}$$

$$CG(X) = \frac{(150.5")\ (13273\ LB) + (433")\ (16400\ LB)}{44070}$$

$$CG(X) = 206"$$

Figure 43. Static Test, Full Load, Center of Gravity Truck Type III.

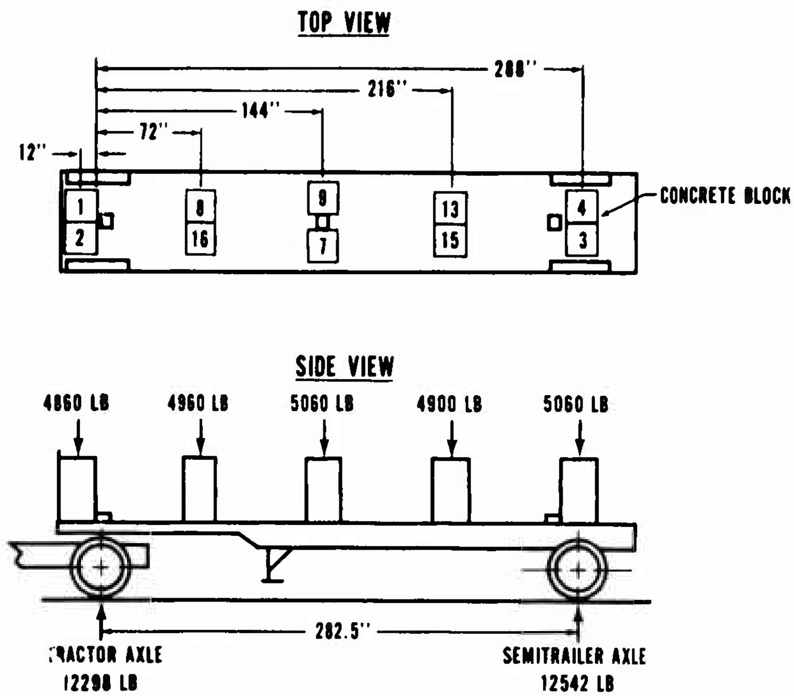


Figure 44. Static Test, Full Load, Truck Type III.

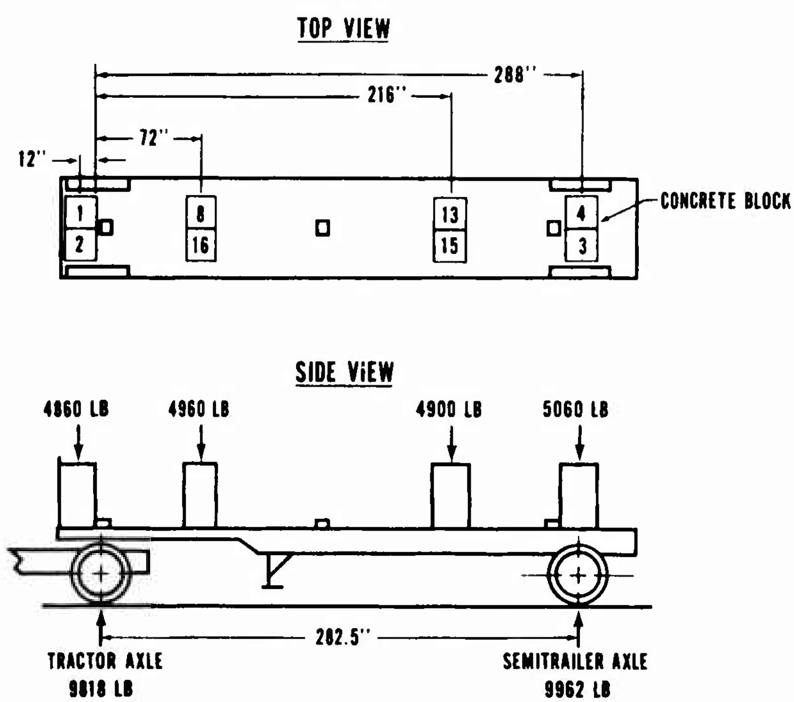


Figure 45. Static Test, Four-Fifths Load, Truck Type III.

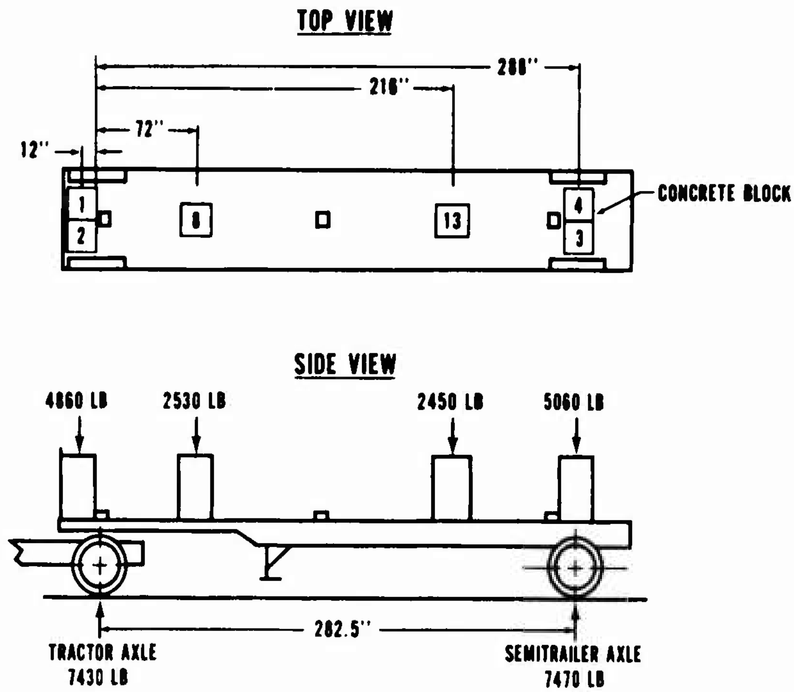


Figure 46. Static Test, Three-Fifths Load, Truck Type III.

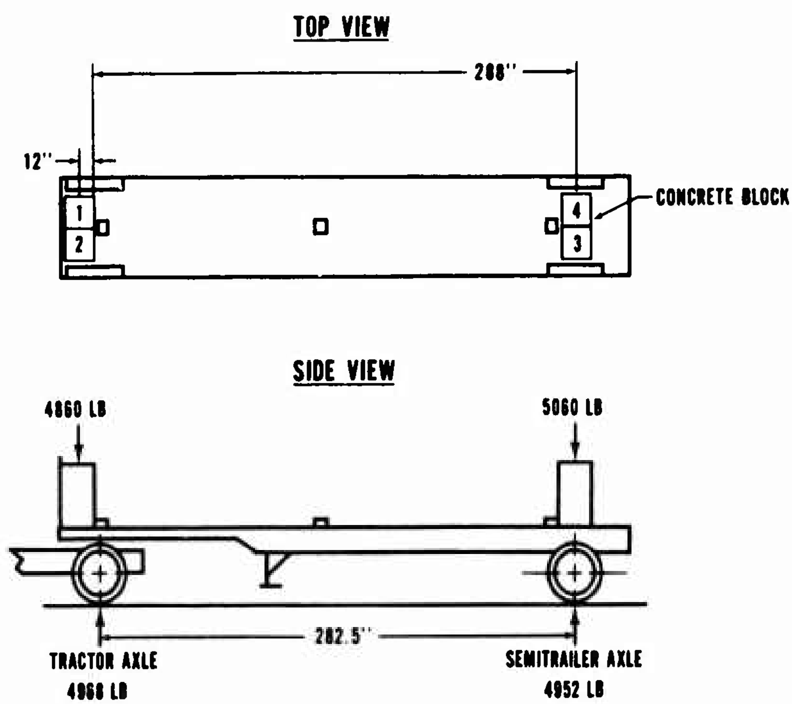


Figure 47. Static Test, Two-Fifths Load, Truck Type III.

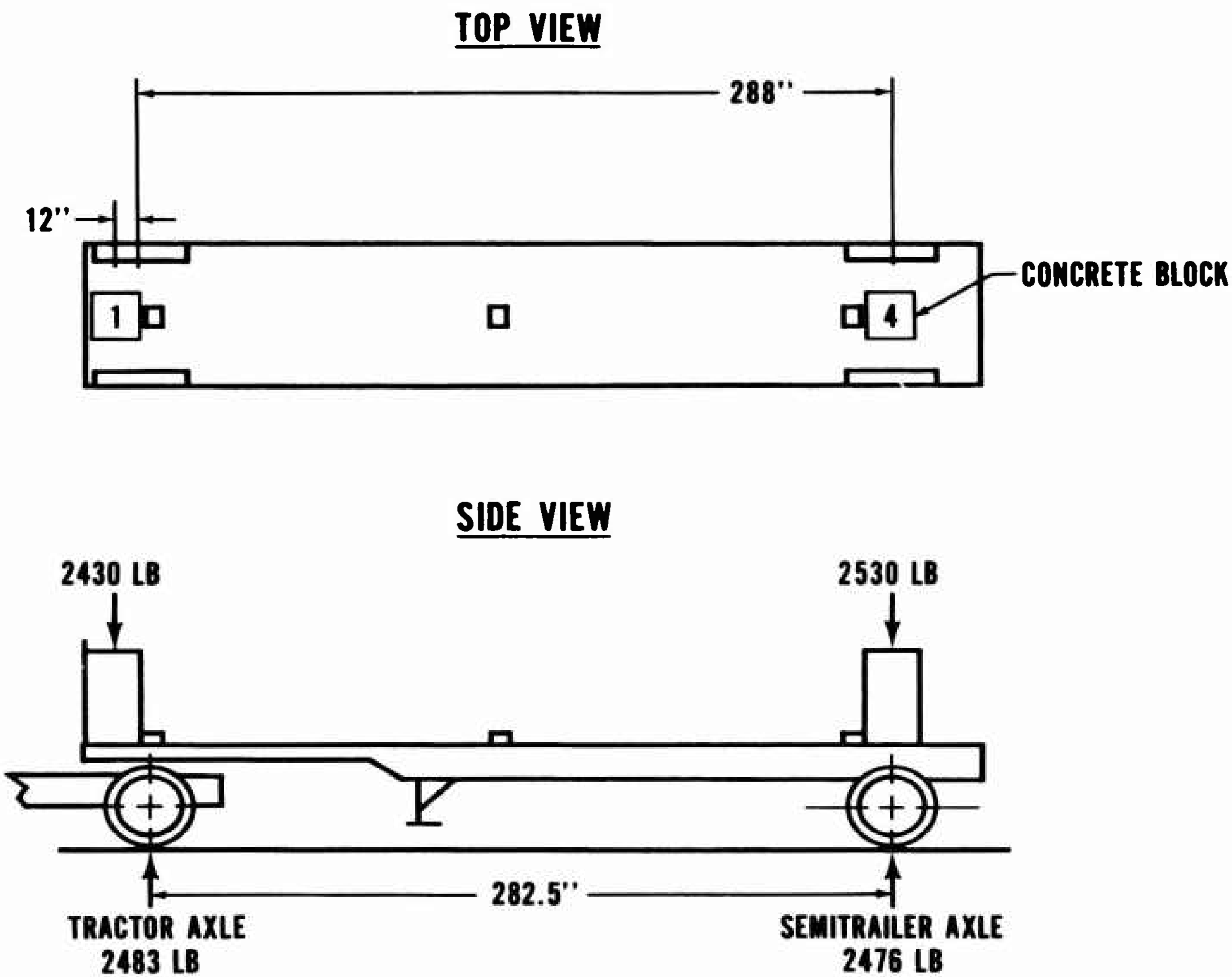


Figure 48. Static Test, One-Fifth Load, Truck Type III.

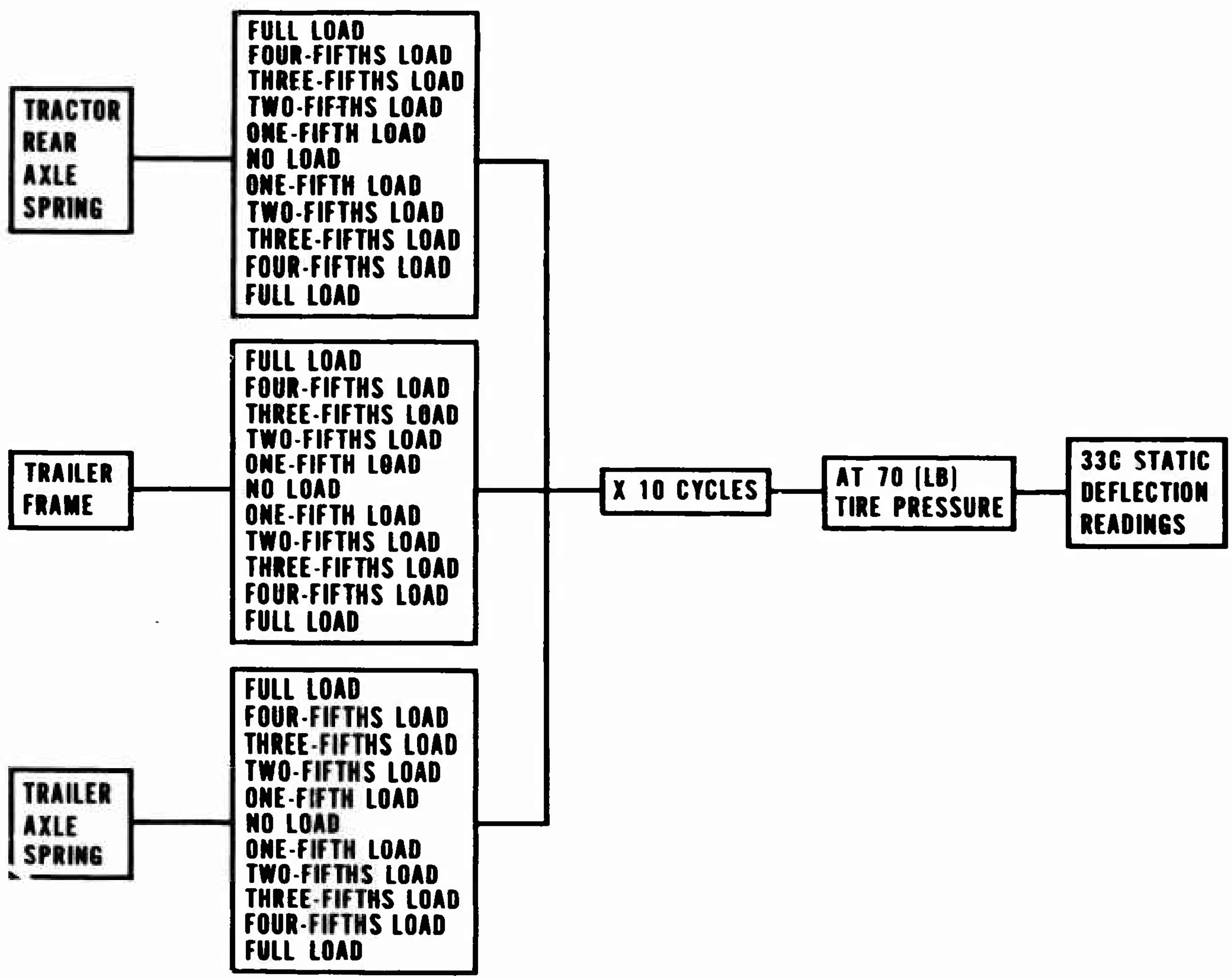


Figure 49. Static Loading Test Procedure, Truck Type III.

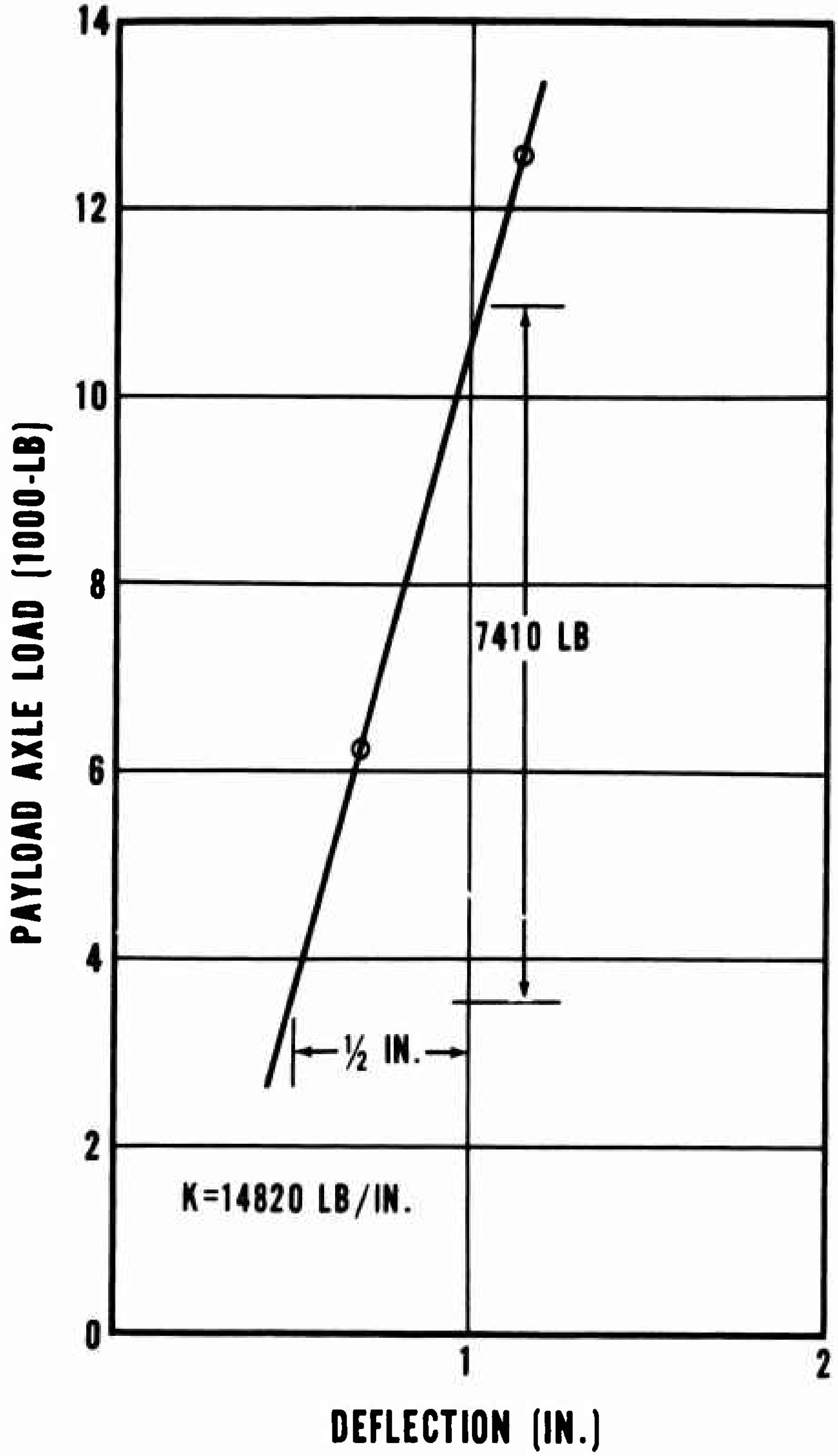


Figure 50. Payload Axle Spring Rate (K) for Tractor Axle on Truck Type III.

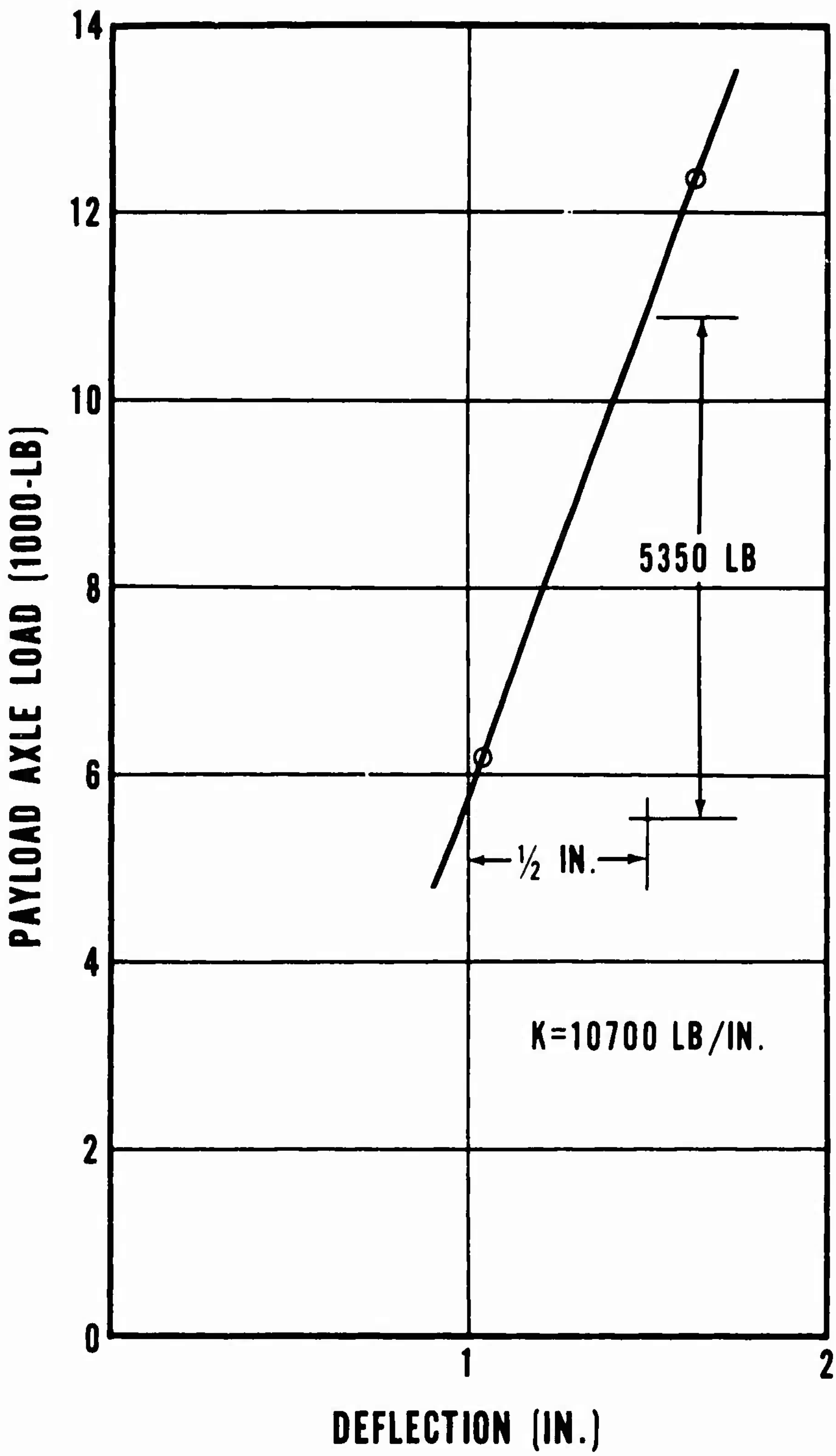
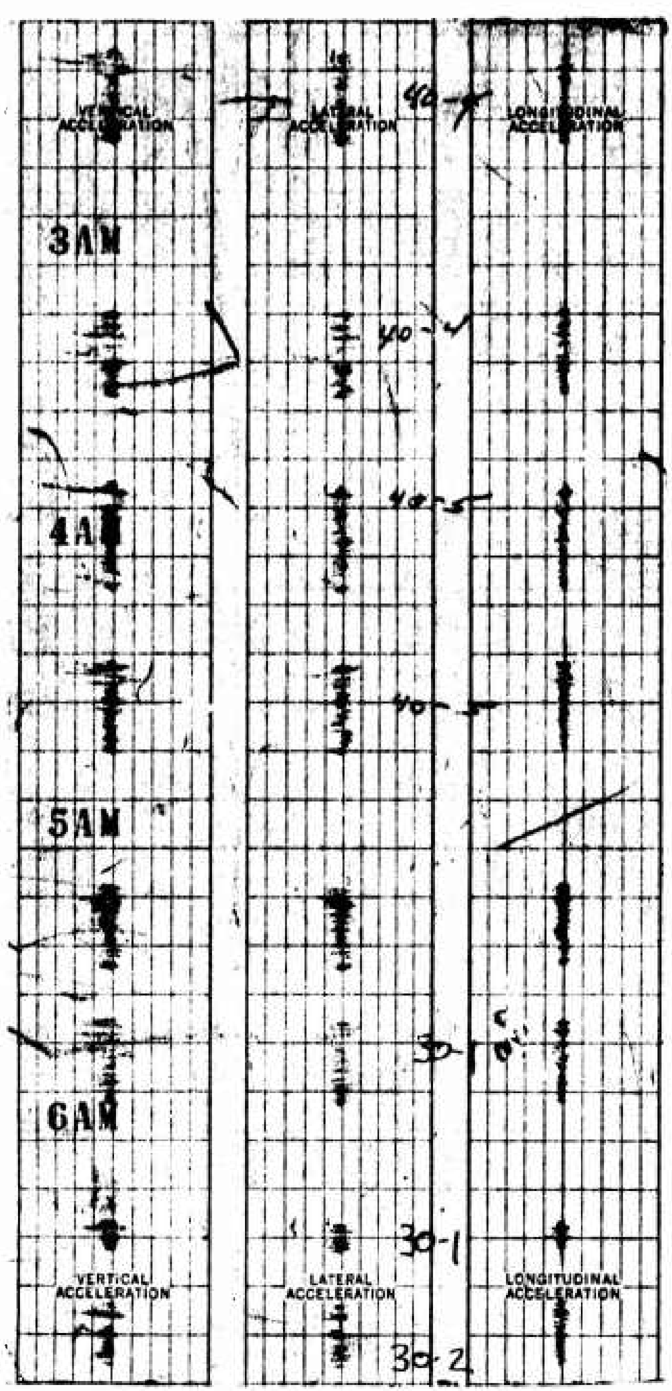


Figure 51. Payload Axle Spring Rate (K) for Trailer Axle on Truck Type III.



Aft Accelerometer Trace

Figure 52. Typical Accelerometer Readout for Truck Type III.

TABLE XXII
TRUCK TYPE III, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 70 PSI TIRE PRESSURE

Block No.	Static Measurements (in.)					Static Deflections (in.)					
	Load (lb)	Front Springs and Tires	Front Tires	Rear Springs and Tires	Rear Tires	Front Springs	Front Tires	Front Springs and Tires	Rear Springs	Rear Tires	Rear Springs and Tires
1, 2, 7, 3, 4	1/2 (12, 450)	7.6250	5.8750	3.3125	3.6250	0.6875	0.2188	0.9063	0.2812	0.3438	0.6250
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.2500	6.0930	3.7812	3.9062	1.1257	0.4368	1.5625	0.4687	0.6250	1.0937
1, 2, 7, 3, 4	1/2 (12, 450)	7.9375	5.8750	3.4375	3.6562	1.0312	0.2188	1.2500	0.3750	0.3750	0.7500
0	0	6.6875	2.6875	2.6875	3.2812	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.6875	5.8750	3.3125	3.6562	0.7812	0.2188	1.0000	0.2500	0.3750	0.6250
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.3437	6.0930	3.8125	3.9375	1.1570	0.4680	1.6250	0.4687	0.6563	1.1250
1, 2, 7, 3, 4	1/2 (12, 450)	7.9375	5.8750	3.4375	3.6562	0.9688	0.2500	1.2188	0.3750	0.3750	0.7500
0	0	6.7187	5.6250	2.6875	3.2812	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.6250	5.8750	3.3125	3.6562	0.6563	0.2500	0.9063	0.2500	0.3750	0.6250
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.2500	6.0930	3.8125	3.9375	1.1257	0.4368	1.5625	0.4375	0.6563	1.0938
1, 2, 7, 3, 4	1/2 (12, 450)	7.9375	5.8750	3.4375	3.6562	1.0312	0.2188	1.2500	0.3438	0.3750	0.7188
0	0	6.6875	5.6562	2.7187	3.2812	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.5000	5.8750	3.3125	3.6250	0.5937	0.2188	0.8125	0.2500	0.3438	0.5938
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.3750	6.0930	3.8125	3.9375	1.2507	0.4368	1.6875	0.4375	0.6563	1.0938

TABLE XXIII

TRUCK TYPE III, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 70 PSI TIRE PRESSURE

Block No.	Static Measurements (in.)					Static Deflections (in.)					
	Load (lb)	Front Springs and Tires	Front Tires	Rear Springs and Tires	Rear Tires	Front Springs	Front Tires	Front Springs and Tires	Rear Springs	Rear Tires	Rear Springs and Tires
1, 2, 7, 3, 4	1/2 (12, 450)	7.9687	5.9062	3.5000	3.6875	0.9375	0.2500	1.1875	0.3438	0.3750	0.7188
0	0	6.7812	5.6562	2.7812	3.3125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.5000	5.8750	3.3125	3.6250	0.5000	0.2188	0.7188	0.2188	0.3125	0.5313
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.3125	6.0937	3.9062	3.9375	1.2188	0.4687	1.6875	0.4999	0.6563	1.1562
1, 2, 7, 3, 4	1/2 (12, 450)	7.9062	5.8750	3.4587	3.6562	1.0312	0.2500	1.2812	0.3437	0.3750	0.7187
0	0	6.6250	5.6250	2.7500	3.2812	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.3750	5.8125	3.6875	3.6562	0.5625	0.1875	0.7500	0.5625	0.3750	0.9375
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.2500	6.0937	3.8437	3.9375	1.0313	0.4687	1.5000	0.4999	0.6563	1.1562
1, 2, 7, 3, 4	1/2 (12, 450)	7.8437	5.8750	3.5000	3.5937	0.8437	0.2500	1.0937	0.5000	0.3125	0.8125
0	0	6.7500	5.6250	2.6875	3.2812	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.6562	5.8750	3.3437	3.6250	0.6562	0.2500	0.9062	0.3124	0.3438	0.6562
1, 2, 8, 16, 9 7, 13, 15, 3, 4	2/2 (24, 820)	8.3125	6.0930	3.7812	3.9062	1.1570	0.4368	1.5938	0.5687	0.6250	1.0937
1, 2, 7, 3, 4	1/2 (12, 450)	7.8750	5.8750	3.4375	3.6562	0.9375	0.2188	1.1563	0.3750	0.3750	0.7500
0	0	6.7187	5.6562	2.6875	3.2812	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE XXIV

TRUCK TYPE III, STATIC VERTICAL MEASUREMENTS AND DEFLECTIONS OF TIRES AND SPRINGS AT 70 PSI TIRE PRESSURE

	Static Measurements (in.)					Static Deflections (in.)					
Block No.	Load (lb)	Front Springs and Tires	Front Tires	Rear Springs and Tires	Rear Tires	Front Springs	Front Tires	Front Springs and Tires	Rear Springs	Rear Tires	Rear Springs and Tires
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.4375	6.0937	4.0625	4.0000	1.3125	0.3750	1.6875	0.6250	0.6875	1.3125
1, 2, 7, 3, 4	1/2 (12, 450)	7.9375	5.9062	3.5625	3.7500	1.0000	0.1875	1.1875	0.3750	0.4375	0.8125
0	0	6.7500	5.7187	2.7500	3.3125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.5312	5.9062	3.3125	3.6875	0.5937	0.1875	0.7812	0.1875	0.3750	0.5625
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.2812	6.0937	3.8750	4.0000	1.4375	0.4375	1.8750	0.4375	0.6875	1.1250
1, 2, 7, 3, 4	1/2 (12, 450)	7.8437	5.9062	3.4375	3.6875	1.1875	0.2500	1.4375	0.3125	0.3750	0.6875
0	0	6.4062	5.6562	2.7500	3.3125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.5312	5.8750	3.4062	3.6562	0.9062	0.2188	1.1250	0.3125	0.3437	0.6562
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.2500	6.0937	3.8437	3.9687	1.0938	0.4687	1.5625	0.4375	0.6562	1.0937
1, 2, 7, 3, 4	1/2 (12, 450)	7.9062	5.9062	3.4375	3.6562	0.9375	0.2812	1.2187	0.3438	0.3437	0.6875
0	0	6.6875	5.6250	2.7500	3.3125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1, 2, 7, 3, 4	1/2 (12, 450)	7.5625	5.9062	3.2812	3.6250	0.5938	0.2812	0.8750	0.2187	0.3125	0.5312
1, 2, 8, 16, 9 7, 13, 15, 3, 4	Full (24, 820)	8.3125	6.0937	3.8437	3.9687	1.0938	0.4375	1.5313	0.4063	0.6562	1.0625

TABLE XXV
TRUCK TYPE III, DYNAMIC LOADING AND OPERATIONAL TEST PROCEDURE

Tire Pressure (70 lb)							
Impact Register Location	Speed (mph)	Load Increment					
Over 5th Wheel	20, 30, 40	Full	4/5	3/5	2/5	1/5	0
Midspan Between 5th Wheel and Semi-trailer Axle	20, 30, 40	Full	4/5	3/5	2/5	1/5	0
Over Semitrailer Axle	20, 30, 40	Full	4/5	3/5	2/5	1/5	0

NOTES:
The variable load and dynamic test conditions were imposed on the vehicle for five complete circuits of the road course.

Variables:

One - Tire Pressure (70 lb)
Six - Load Increments (Full, 4/5, 3/5, 2/5, 1/5, 0)
Three - Speed (20, 30, 40)

There were 540 readings for three recorders.

TABLE XXVI
LOADING ARRANGEMENT, STATIC AND DYNAMIC TESTS, TRUCK TYPE III

Full Load		4/5 Load		3/5 Load		2/5 Load		1/5 Load	
Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)	Block No.	Wt (lb)
1	2, 430	1	2, 430	1	2, 430	1	2, 430	1	2, 430
2	2, 430	2	2, 430	2	2, 430	2	2, 430		
8	2, 530	8	2, 530	8	2, 530				
16	2, 430	16	2, 430						
9	2, 530								
7	2, 530								
13	2, 450	13	2, 450	13	2, 450				
15	2, 450	15	2, 450						
3	2, 530	3	2, 530	3	2, 530	3	2, 530		
4	2, 530	4	2, 530	4	2, 530	4	2, 530	4	2, 530
	22, 635		17, 575		14, 900		9, 920		4, 960
Payload Axle Load									
Tandem Tractor	Tandem Semi-trailer	Tandem Tractor	Tandem Semi-trailer	Tandem Tractor	Tandem Semi-trailer	Tandem Tractor	Tandem Semi-trailer	Tandem Tractor	Tandem Semi-trailer
12, 298	12, 542	9, 818	9, 962	7, 430	7, 470	4, 968	4, 952	2, 483	2, 476